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# INTEGRAL AIRCRAFT FUEL TANK LEAK CLASSIFICATION

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A parametric study has been conducted to investigate external leakage from aircraft integral fuel tanks. The effects of the following parameters on the rate of surface dispersion of fuels were examined: fuel type, leakage rate, surface material, fuel and surface temperature, air flow rate over the test surface, and surface angle of inclination.

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The dispersing fuel films were found to be very thin (0.05 mm/0.002 in.); i.e., limited liquid volume flow results in extensive surface coverage. Fuels of low volatility such as JP-5 and JP-8 dispersed at a faster rate over the surface and exhibited a greater propensity for dripping than those of high volatility (AvGas and JP-4). Low temperatures, inclined surfaces, and polyurethane latex surface coating enhanced fuel dripping from the test surface.

Fuel flow rates required to support sustained burning at the leakage site were investigated with JP-4, JP-5, JP-8, JP-4/JP-8 mixtures, and AvGas. The measurements were conducted at temperatures ranging from 3.3°C to 98°C (38°F to 209°F). The vapor pressure of the fuel at the test temperature has a very pronounced effect on the propensity of the leaking fuel to sustain burning. The minimum volume flow rates required for sustained burning ranged from 0.2 mℓ/min. [AvGas at 23°C (73°F)] to 9 mℓ/min. [JP-5 at 98°C (208°F)].

As a result of this investigation, a revision to Air Force Technical Order 1-1-3 for classifying integral fuel tank external leaks was developed and provided to the AFSC Aeronautical Systems Division (ASD) and AFLC Air Force Acquisition Logistics Division (AFALD) for evaluation and implementation action. The proposed revised criteria provide for a 6 minute leak assessment period and, depending on the specific fuel, a greater tolerable range of fuel leakage. The adoption of the revised criteria will result in a relaxation of integral fuel tank external leak repair requirements while shortening inspection time requirements. This, in turn, should produce significant cost savings without increasing the risk of accidents caused by fuel tank leaks.

## FOREWORD

This is an interim Technical Report prepared by Monsanto Research Corporation, Dayton Laboratory. The effort was sponsored by the Air Force Aero Propulsion Laboratory, Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright-Patterson AFB, Ohio under Contract No. F33615-78-C-2023 for the period 1 September 1978 to 15 April 1979. The work herein was accomplished under Project 3048, Task 304807, Work Unit No. 30480784, with Mr. R. E. Cretcher, AFAPL/SFH, as Project Engineer. Dr. Leo Parts of Monsanto Research Corp. was technically responsible for the work. Other Monsanto Research Corporation's personnel participating were: Mr. T. J. Bucher, Mr. J. D. Tobias, and Mrs. C. Fritsch.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

## LIST OF ILLUSTRATIONS

KEY TO FIGURES DESCRIBING SURFACE-DISPERSION OF FUELS

Key 1. Effect of Fuel Flow Rate (1 to 1000 μℓ/min.) at Fixed Angles of Panel Inclination (0°, 5°, 10° and 90°).

Key 2. Comparison of the Dispersion of Different Fuels on Alclad Surface at Fixed Flow Rates (5, 10, 25, 50, 100 and 250 μℓ/min.) and Angles of Inclination (0°, 5° and 10°).

Key 3. Effect of Temperature on the Rates of Surface-Dispersion of JP-4(HVP) and JP-5 at Fixed Fuel Flow Rates (10, 25 and 50 μℓ/min.).

Key 4. Effect of Temperature on the Rate of Surface-Dispersion of JP-8 at Fixed Fuel Flow Rates (50 and 100 μℓ/min.)

Key 5. Effect of Air Flow Rate (6.1 m/sec and none) on the Rate of Surface-Dispersion of JP-4(HVP).

Key 6. Effect of Air Flow Rate (6.1 m/sec and none) on the Rate of Surface-Dispersion of JP-5.

Key 7. Effect of Air Flow Rate (6.1 m/sec and none) on the Rate of Surface-Dispersion of JP-8.

Key 8. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of Jet Fuels at the Fixed Fluid Flow Rate of 10 μℓ/min.

Key 9. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of Jet Fuels at the Fixed Fluid Flow Rate of 100 μℓ/min.

Key 10. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of JP-4(LVP) and JP-4(HVP) at the Fixed Fluid Flow Rate of 250 μℓ/min.

Key 11. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of JP-4(LVP) and JP-4(HVP) at the Fixed Fluid Flow Rate of 500 μℓ/min.

Key 12. Effects of Fuel Flow Rate (10 to 500 μℓ/min.) on the Rates of Surface-Dispersion of Jet Fuels on a Horizontally Mounted, Polyurethane Latex-Coated Panel.

Key 13. Comparison of the Dispersion of Different Fuels on Unclad Aluminum Alloy and on Polyurethane Latex-Coated Surface.

KEY TO FIGURES DESCRIBING SURFACE-DISPERSION OF FUELS (continued)

Key 14. Effect of Panel Surface Composition (Alclad vs. Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-5 at the Fixed Fluid Flow Rates of 10 and 25 μℓ/min.

Key 15. Effect of Panel Surface Composition (Alclad vs. Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-8 at the Fixed Fluid Flow Rates of 25 and 50 μℓ/min.

Key 16. Effect of Panel Surface Composition (Alclad, Unclad Aluminum Alloy and Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-4(LVP) and JP-4(HVP) at the Fixed Fluid Flow Rate of 100 μℓ/min.

Key 17. Effect of Panel Surface Composition (Alclad, Unclad Aluminum Alloy and Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-5 and JP-8 at the Fixed Fluid Flow Rate of 100 μℓ/min.

LIST OF TABLES

LIST OF TABLES (continued)

## INTRODUCTION

Leakage of fuel from integral fuel tanks in aircraft can constitute a potential fire hazard. The Air Force, commercial airline companies, and airframe manufacturers have established their own criteria for integral fuel tank leak classification [1-3]. The criteria established by the different organizations are not uniform (see Table 1). Also, the directives for corrective measures differ. Furthermore, there does not appear to be an experimentally established basis for the corrective measures required.

TABLE 1. AIRCRAFT FUEL LEAK CLASSIFICATIONS

| Leak classification | Air Force<br>Spot diameter (in.) after 30 min. | Boeing 707<br>Spot diameter (in.) after 15 min. | Delta Airlines<br>Spot diameter (in.) |
|---|---|---|---|
| Stain | | | 0.5 to 0.75 |
| Slow seep | <0.75 | ≤1.5 | |
| Seep | <1.5 | ≤4 | ≤1.5 |
| Heavy seep | <3 (no drip) | ≤6 | ≤3.5 to 4 |
| Running leak | Drips or runs from surface. | In excess of heavy seep. Will drip or run from surface. | 4 to 5 |

Unnecessary grounding of aircraft for the repair of leaks that do not constitute a real hazard represents a needless expense. It can also cause delays of operational missions.

Because of these factors, the Fire Protection Branch of the Air Force Aero Propulsion Laboratory (AFAPL) initiated a review of Air Force T.O. 1-1-3 criteria for integral fuel tank leak classification. The purpose of this review was to either validate current criteria or to recommend revised criteria where appropriate. Such revisions were to reduce maintenance time and cost, without compromising personnel and aircraft safety on the ground and in flight. Monsanto Research Corporation (MRC), under contract and in cooperation with AFAPL, was responsible for providing a reliable experimental data basis for the review of leak criteria.

Two aspects of fuel leakage were of major interest in this investigation:

(1) The rate of fuel dispersion from the leakage site over the external surface of the integral fuel tank.

(2) The minimum fuel leakage rate at which sustained burning (not just ignition and transitory burning) occurs.

The theoretical basis has not as yet been developed for treating surface-dispersion of complex liquid systems. It is thus not feasible to model a multicomponent system that contains constituents that vaporize during the dispersion [4]. Therefore, it was decided to establish the basis for the review of T.O. 1-3-3 experimentally, by simulating external leakage from integral aircraft fuel tanks with a specially designed test apparatus.

The following fuels were used in this program:

JP-4(LVP)[a]
JP-4(HVP)[b]
JP-5
JP-8
JP-4(HVP)/JP-8 (10/90 volume % mixture)
JP-4(HVP)/JP-8 (50/50 volume % mixture)
AvGas

As a broad objective, the physically observable and measurable parameters of fuel leakage and associated fire hazard were to be related to the measured values of fuel flow rates.

An apparatus was designed and fabricated for simulating leakage from an integral fuel tank under controlled conditions. The compositions, and physical and ignitability properties of jet fuels used in this work were determined. Subsequently, the effects of the following variables on the rates of surface-dispersion of fuels were determined:

(1) Fuel flow rate (1 to 1400 μℓ/min.; 0.002 to 2.84 fl oz/hr).

(2) Air flow rate (0 to 20 ft/sec; 0 to 13.6 miles/hr).

(3) Temperature (3.3°C to 32°C; 38°F to 90°F).

(4) Angle of inclination of the panel (0°, 5°, 10°, 90°).

(5) Surface composition of the panel (Alclad, unclad aluminum alloy, and polyurethane latex-coated surface).

The data in parentheses indicate the range within which the experimental parameters were varied.

The environmental and fuel flow conditions under which dripping from the panel surface occurred were determined. The miminum fuel flow rates required to support sustained burning were also determined.

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[a]Low vapor pressure sample.

[b]High vapor pressure sample.

# EXPERIMENTAL

## FUELS AND THEIR PROPERTIES

### Fuels

The fuels used in this program were supplied by the Air Force Project Engineer. He obtained the following fuels from the AFAPL's storage facility at Wright-Patterson AFB: JP-4(LVP), JP-5, JP-8, and AvGas (octane 100/130). The high vapor pressure sample of JP-4 was supplied by the 27th Supply Squadron at Cannon AFB, NM.

Mixtures of JP-4(HVP) and JP-8 were prepared in the 10/90 and 50/50 volume ratios from the fuels as supplied.

The jet fuels were characterized by determining certain physical properties, and ignition and flammability characteristics. The chemical compositions were also determined. The measurement methods are referenced below. The results are tabulated in the Appendix.

### Physical Properties

The results of physical properties measurements, including those of vapor pressures, densities, viscosities and surface tensions, are summarized in Table A-1 and in Figures 15 to 23 in the Appendix.

The vapor pressures of jet fuels were determined with a micro vapor pressure apparatus [6,7] at 0°C, 21.1°C, and 37.8°C (32°F, 70°F, and 100°F).

The densities were measured with a calibrated dilatometer at 0°C, 25°C and 37.8°C (32°F, 77°F, and 100°F).

Flow rate measurement through capillary tubing was used for kinematic viscosity determinations [8] at -17.8°C, 25°C, and 37.8°C (0°F, 77°F, and 100°F).

Surface tensions of the fluids were determined by the capillary rise method at 0°C, 21.1°C, and 37.8°C (32°F, 70°F, and 100°F).

### Ignitability and Flammability Characteristics

The flash points and fire points of the fuels were determined by the Pensky-Martens closed cup method [9]. The results are presented in Table A-2 in the Appendix.

## Chemical Compositions

A simulated distillation procedure, based upon chromatographic separation of the hydrocarbon components in the jet fuels [10], was used for compositional analysis. The analyses were conducted with a Hewlett-Packard Model 5730A gas chromatograph, equipped with a flame ionization detector. The column packing consisted of 3% OV-1 on Chromosorb W. The temperature rise was programmed at 8°C per minute up to 200°C. The column temperature was maintained at 200°C for eight minutes. Helium served as the carrier gas, at the flow rate of 30 mℓ/min.

The simulated distillation curves for the four jet fuels are shown in Figure 19 in the Appendix. The compositions of the fuels are presented in Figures 20 to 23 in the Appendix. The compositions are based upon calibration experiments with n-paraffins.

## APPARATUS AND EXPERIMENTAL PROCEDURES FOR INTEGRAL FUEL TANK LEAK CHARACTERIZATION

Figure 1 is a view of the apparatus designed and fabricated for the characterization of integral fuel tank leaks. There was a small, centrally located orifice in the metal panel; it served as a simulated leakage source. The panel was supported by a 45.7 cm x 61.0 cm x 61.0 cm (18 in. x 24 in. x 24 in.) Unistrut channel frame [2.06 cm (13/16 in.) wide channel]. A syringe pump (see Figure 2) and a metal mirror, mounted under a 45° angle with reference to the panel surface, were also supported by the frame. The metal mirror was used for visually monitoring the surface dispersion of the fluids on the underside of the panel.

The plate was aligned horizontally by means of three adjustable, threaded legs. A bubble-type leveler on the panel surface was used for the initial leveling adjustments. More precise leveling was subsequently achieved by centering the fuel droplet during the flow.

The metal panel could be positioned at an angle with reference to the horizontal plane. A screw mechanism was used for this adjustment. In the experiments conducted, 0°, 5°, 10°, and 90° angles of inclination were used. For the latter measurements, the apparatus was placed on its side.

For measurements at temperatures other than the ambient, a panel with a metal rim was used. It was fabricated from a flat panel by equipping it with 5.1 cm (2 in.) high rim. The rim was sealed to the upper panel surface with high-temperature epoxy adhesive; it was welded in the corners. The desired panel surface temperature was attained and maintained by either cooling or heating water in the pan to the required temperature. The temperature of the panel surface was measured with a Tele-Thermometer, Model 42SC, equipped with sensor No. 409, from Yellow Springs Instrument Company.

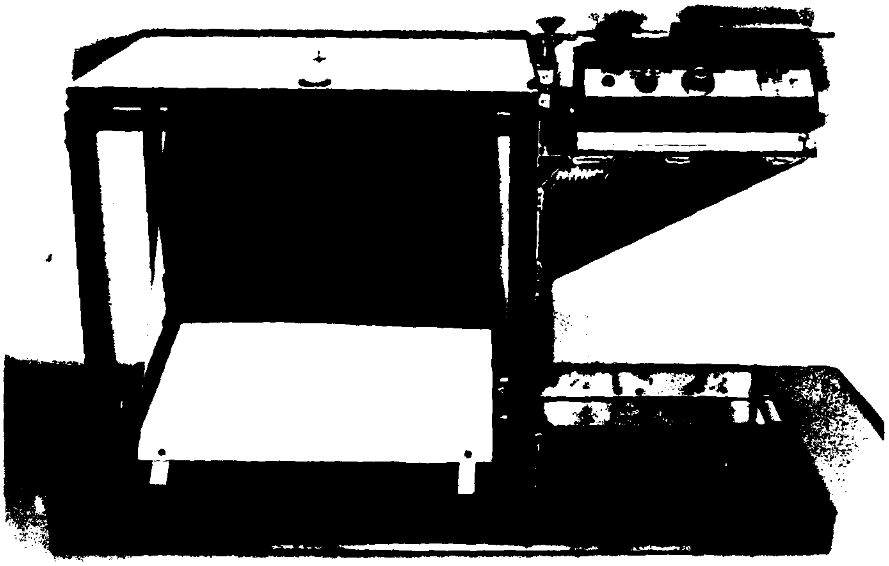


Figure 1. Apparatus for fuel leakage studies.

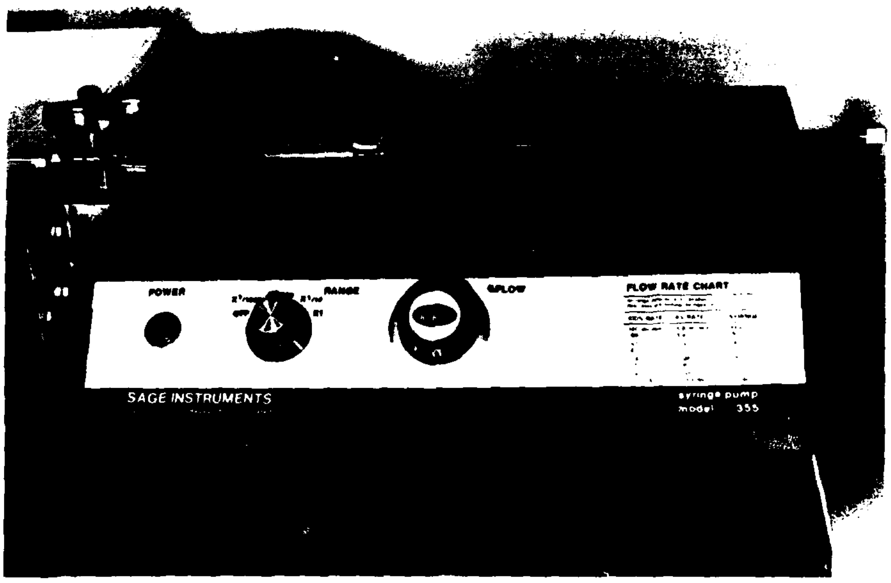



Figure 2. Syringe pump for fuel delivery.

Fuel was supplied at a constant rate by means of a syringe pump (Sage Instruments, Model 355; see Figure 2) whose delivery rate could be varied from <1 μℓ/min. to 140 mℓ/min. The fuel was pumped through a 1.59 mm (1/16 in.) OD stainless steel tubing of 0.46 mm (0.018 in.) internal diameter. For experiments at room temperature, the transfer tubing was sealed into a small orifice in the center of the 45.7 cm x 61.0 cm x 0.32 cm (18 in. x 24 in. x 1/8 in.) aluminum panel (see Figure 3). For dispersion experiments at other temperatures and for burning experiments, a panel was equipped with a Swagelok fitting for fastening the tubing.

Prior to experiments, the underside of the panel was preconditioned by wiping it with a paper towel moistened with the fuel that was to be used in subsequent experiments. A thin film of low-volatility hydrocarbons was thereby deposited on the panel surface simulating a contaminated fuel tank surface.

During surface-dispersion rate measurements, the spot diameter was measured with a ruler at selected time intervals, without allowing the latter to contact the fuel. The spots were readily visible (see Figure 4 for direct view of spot formed by JP-4, high vapor pressure sample); there was no need to apply dyed talcum [2] onto the surface to enhance spot visibility.

A propane torch with a 7.6 cm (3 in.) long brush flame was used as the ignition source in experiments in which leakage rates for support of sustained burning were determined. The flame was traversed over the central area of the spot at 3-second intervals. If the fuel continued to burn in a stable manner for 30 seconds, the leakage rate was considered to be sufficiently high to support sustained burning.

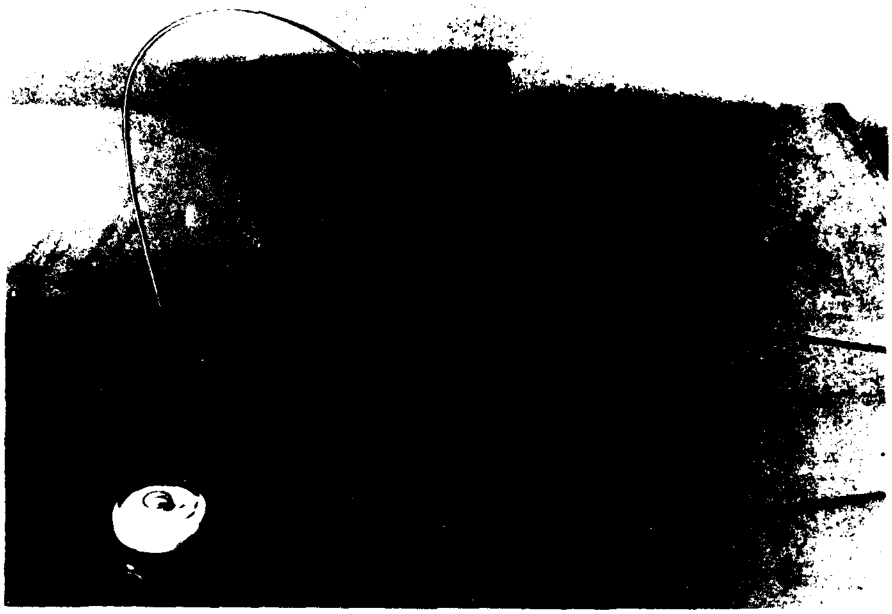


Figure 3. Fuel transfer line, bonded to aluminum surface.

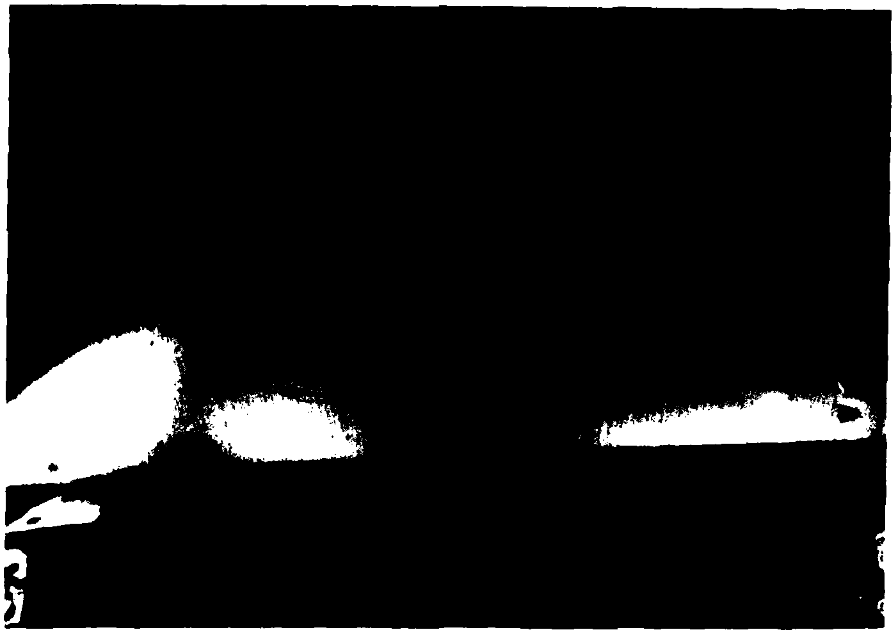


Figure 4. Dispersion of JP-5 on the underside of the aluminum surface.

## RESULTS AND DISCUSSION

### SURFACE-DISPERSION OF FUELS

The matrix of experiments pertaining to fuel surface-dispersion measurements is presented in Table 2. The results of these parametric experiments are discussed below with the support of illustrative, representative figures. Most of the experimental data are presented in the form of tables and figures in the Appendix. Keys have been devised for these tables and figures to facilitate locating the data.

#### Fuels and the Effect of Flow Rate

When fuels leak at a slow rate through a small orifice onto the underside of flat, horizontally mounted panels, they disperse in a circular manner (see Figure 4). For fuels of low volatility, the rate of spreading, in terms of surface area coverage, is nearly linear (see the data for JP-5 and JP-8 in Figures 5 and 6), i.e.,

$$dA = kdt \tag{1}$$

In Equation 1, A represents area, t designates time, and k is the rate constant for surface-dispersion. Based on Equation 1, the spot diameter of low-volatility fuels increases proportionally with $t^{\frac{1}{2}}$ (see Figure 7).

It was learned in this work that the spreading fuel film is very thin. Consequently, small quantities of fuel cover large areas. Fuel film thickness was found to increase with the rate of leakage. At sufficiently high fuel flow rates, gravitational force became larger than the interfacial and cohesive forces, and dripping of fuel occurred. We will use the spreading of JP-8 on Alclad surface at 23°C, at an air flow rate of 6.1 m/sec (13.6 miles/hr), to illustrate the latter statements.

At the flow rate of 5 μℓ/min., only 0.15 mℓ of fuel flowed onto the surface in 30 minutes. At that time, the average spot diameter was 12.2 cm (4.8 in.) and the liquid film thickness was ≤0.013 mm (0.50 mil). When the fuel flow rate was increased to 25 μℓ/min., 0.75 mℓ of fuel flowed onto the surface in 30 minutes. The average spot diameter was 19.2 cm (7.6 in.) and the film thickness was ≤0.026 mm (1.0 mil). Dripping of this fuel was observed when its flow rate was increased to 0.25 mℓ/min.

The relatively more volatile fuels (i.e., JP-4 and AvGas) spread less rapidly and their rate of spreading, in terms of area coverage was found not to be proportional to time (see Figures 5 and 6). The reduced and nonlinear spreading rates, and the occurrence of dripping only at higher flow rates are attributed to significant partial volatilization of these fuels.

TABLE 2. MATRIX OF EXPERIMENTS FOR FUEL SURFACE-DISPERSION MEASUREMENT[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (µℓ/min.) / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | ● | ● | ● | ● | | ● | | | | | |
| 0 | 10 | | ● | | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 25 | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 50 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● |
| 0 | 100 | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | ● | ● | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ● | ● | | ● | ● | | | | ● | | | |
| 0 | 1000 | | | | ● | ● | | | ● | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| 5 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ● | | | | | | | | |
| 5 | 500 | | | | ● | ● | | | | | | | | | | |
| 10 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ● | ● | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ● | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

TABLE 2 (continued)[a]

| Angle (deg) | Panel / Fuel flow rate (μℓ/min.) / Fluid | Alclad | | | | Unclad aluminum alloy | | | | Polyurethane latex-coated surface | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4 (LVP)[b] | JP-4 (HVP)[c] | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | ● | | | | | | | | | |
| 0 | 5 | ● | ● | ● | ● | | | | | | | | |
| 0 | 10 | ● | ● | ● | ● | | | | | | | ● | |
| 0 | 25 | ● | ● | ● | ● | | | | | | | ● | ● |
| 0 | 50 | ● | ● | ● | ● | | | | | | | ● | ● |
| 0 | 100 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| 0 | 250 | ● | ● | ● | ● | | | | | ● | ● | | |
| 0 | 500 | ● | ● | | ● | | | | | ● | ● | | |
| 0 | 1000 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | ● | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

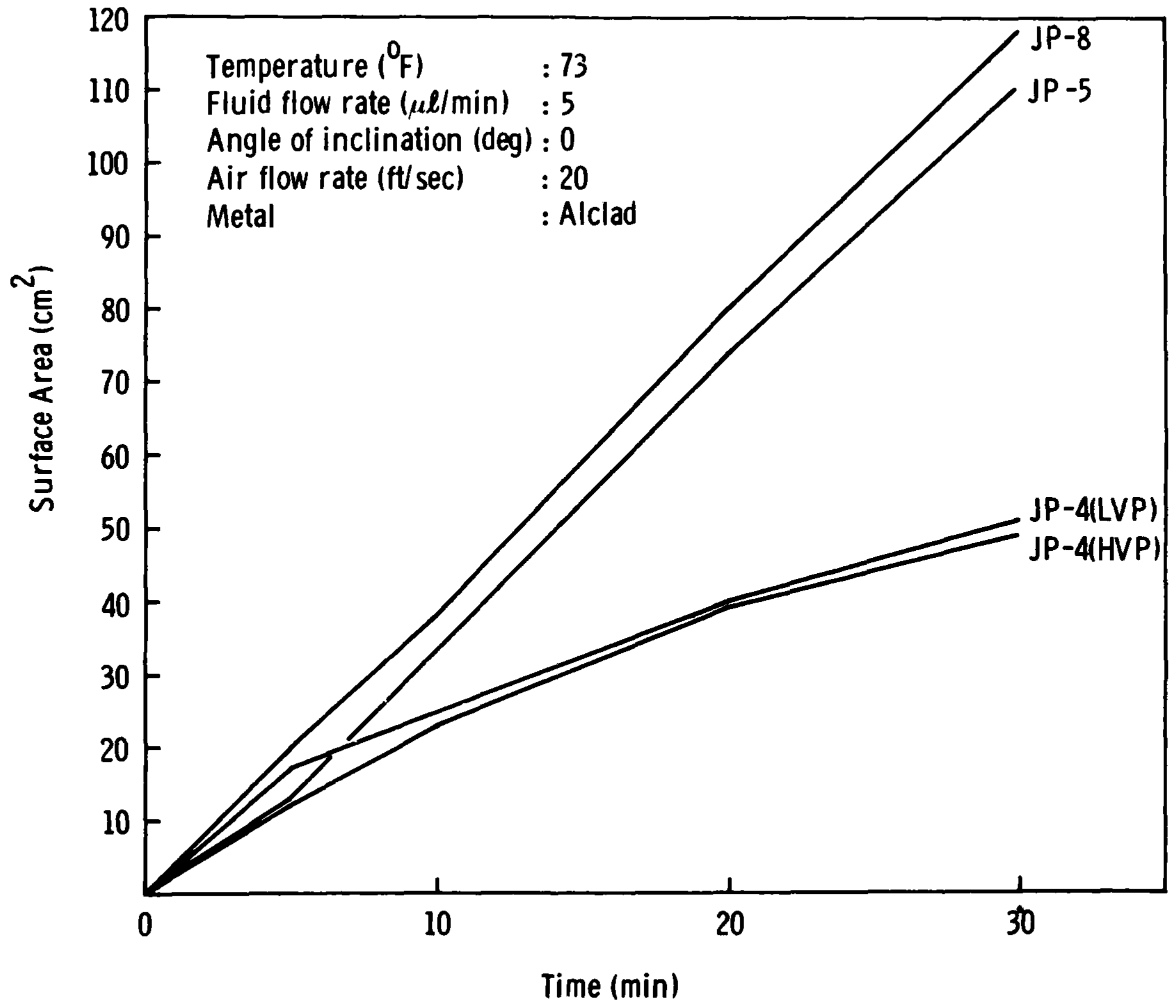



Figure 5. Spot surface areas of jet fuels, at a flow rate of 5 $\mu\ell$/min., as functions of time.

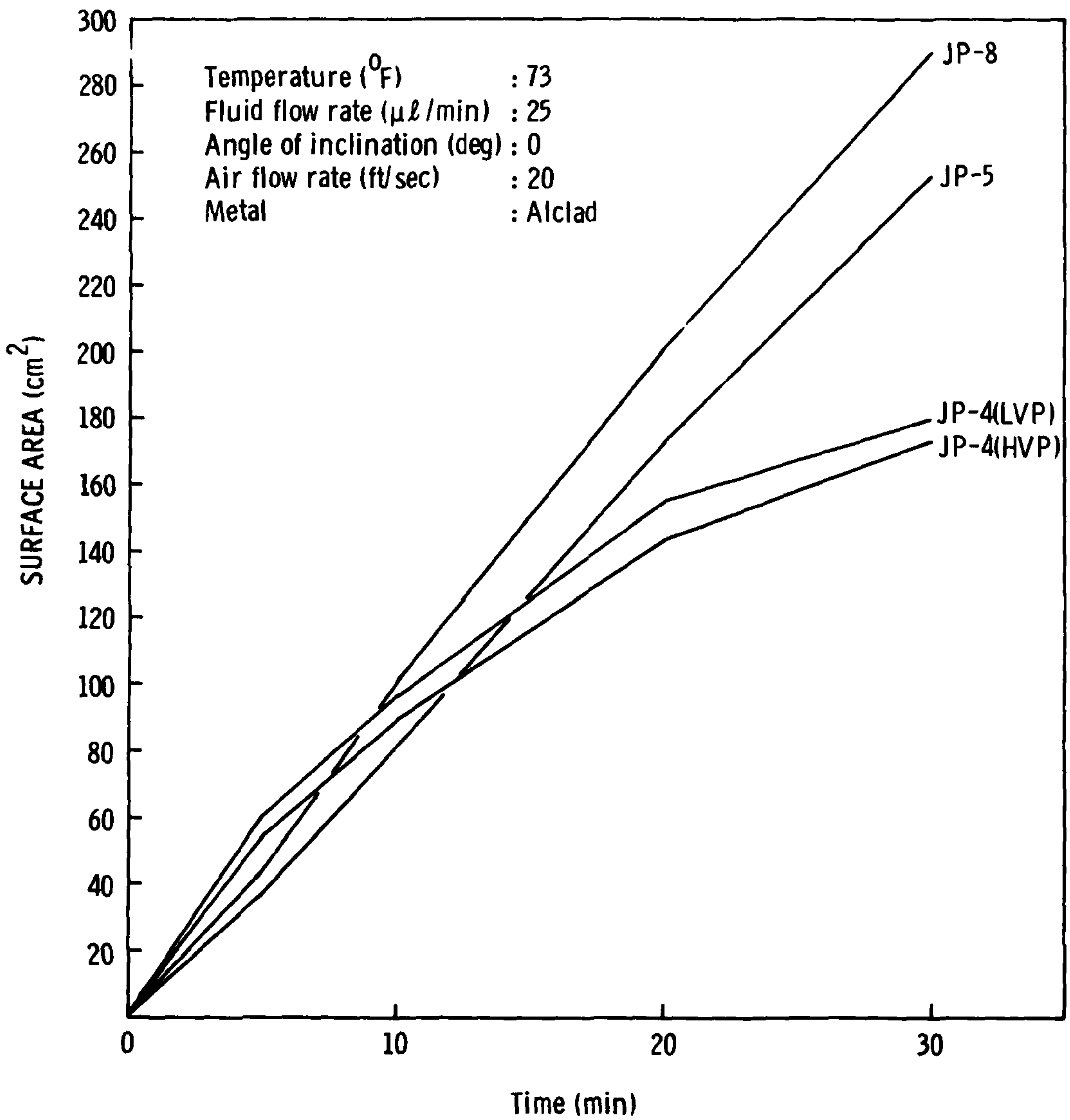



Figure 6. Spot surface areas of jet fuels, at a flow rate of 25 μℓ/min., as functions of time.

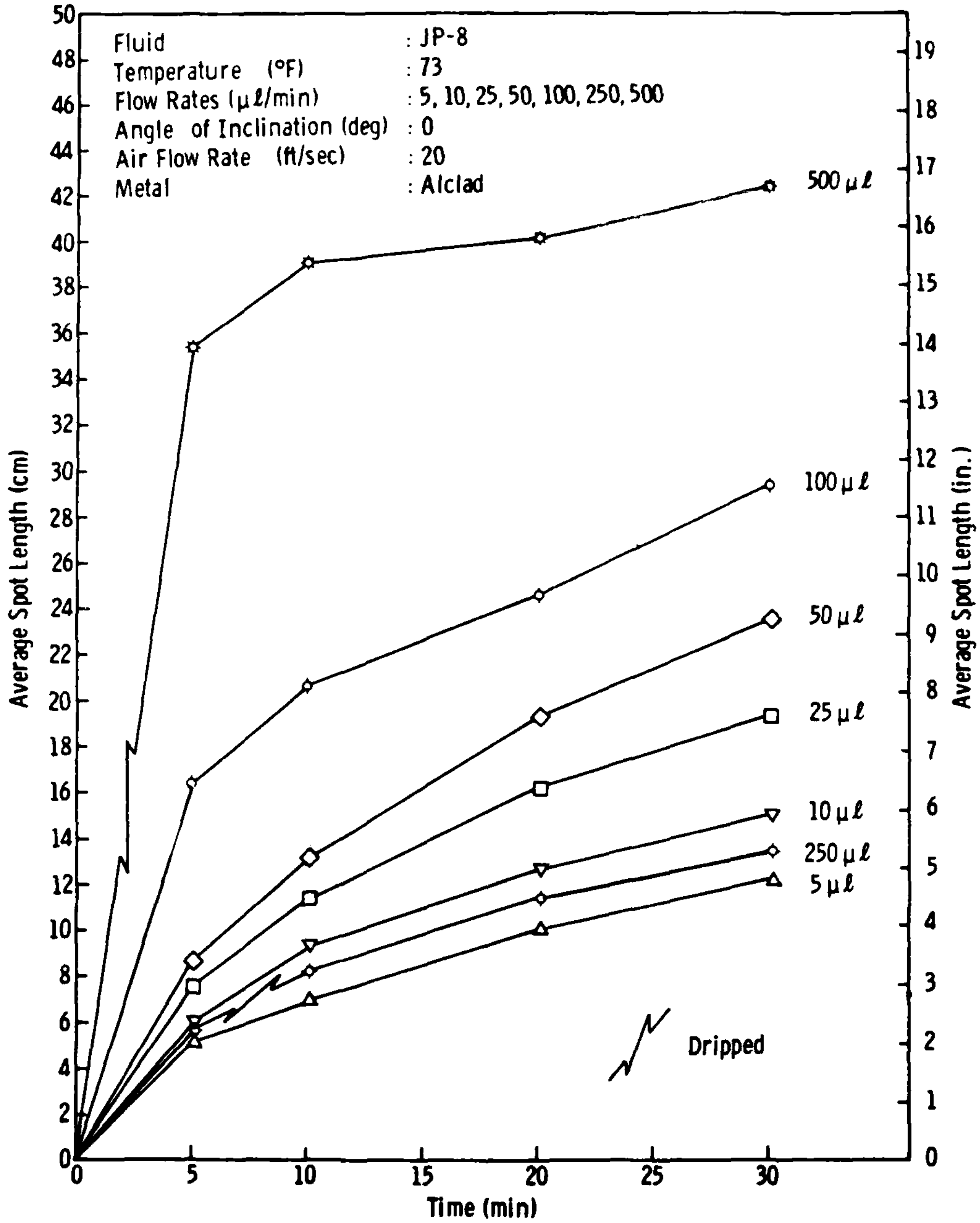



Figure 7. Rates of surface-dispersion of JP-8 at different fluid volume flow rates.

Representative data for the rates of spreading of a fuel [JP-4 (HVP)] at different leakage rates, under a set of selected conditions, are shown in Figure 8.

The spot lengths (or diameters in cases of symmetrical dispersion) for the four jet fuels at the end of 30-minute experiments, as functions of fuel flow rates, are depicted in Figure 9. It should be noted that a spot diameter equal to or greater than 15.2 cm (6 in.) was attained in 30 minutes with all fluids at the volume flow rate of 25 μℓ/min. (1.5 mℓ/hr; 0.051 fl oz/hr).

Table A-15 in the Appendix contains the data indicating volume flow rates at which dripping of fuel from the panel surface was observed.

### Effect of Temperature

Temperature affects the rate of surface-dispersion of fuels and also the propensity of leaking fuels to drip. Surface-dispersion of fluids is affected by several physical properties (i.e., viscosity, surface tension, and vapor pressure). Therefore, the rate of surface dispersion of different fuels was found to be affected differently by temperature variation.

JP-4(HVP), a fuel of high vapor pressure, dispersed at a slower rate at higher temperature (see Figures 10 and 11). Apparently, vaporization reduced the quantity of dispersing fuel.

In contrast, the rates of dispersion of JP-8 (see Figure 10) and JP-5, fuels of low vapor pressure, increased with temperature. The reductions of viscosity and surface tension with increasing temperature control the rate of surface-dispersion with these fuels in the temperature interval [3.3°C to 32°C (38°F to 90°F)] covered in this study.

The propensity of fuels to drip was found to diminish with increasing temperature (see Table A-15). Whereas JP-8 dripped in quiescent atmosphere at 3.3°C (38°F) at a flow rate of 50 μℓ/min., at 23°C (73°F) dripping occurred at 100 μℓ/min., and at 33°C (90°F) no dripping was observed even at the latter flow rate.

### Effect of Air Flow Rate

Figures 68 to 82 in the Appendix depict the effect of air flow past the fuel film on the rate of surface-dispersion. At the rates used in this work [0 and 6.1 m/sec.; (0 and 20 ft/sec.; 0 and 13.6 miles/hr)] the air flow had no significant effect on the fuel dispersion.

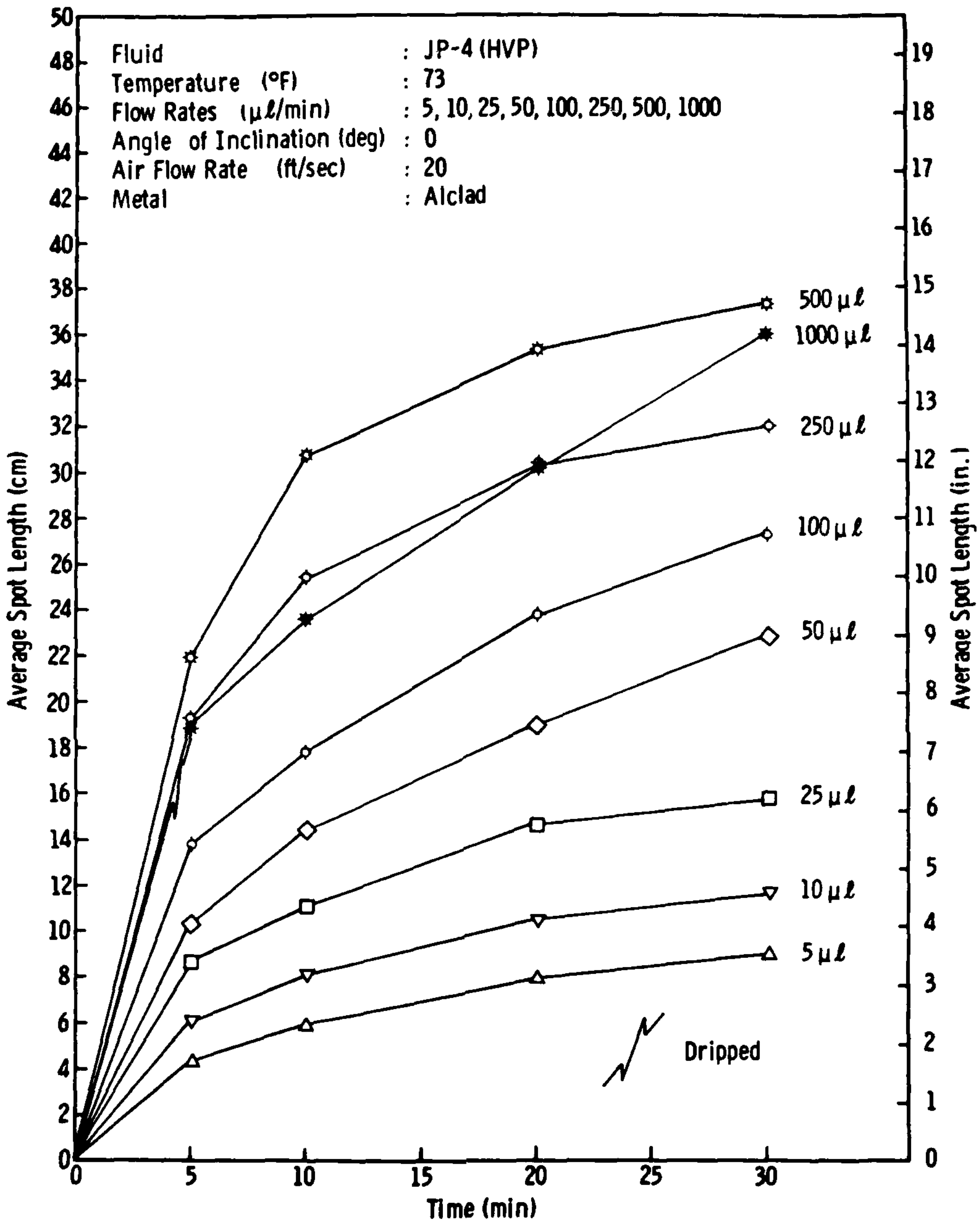



Figure 8. Surface-dispersion of JP-4(HVP) at different fluid volume flow rates.

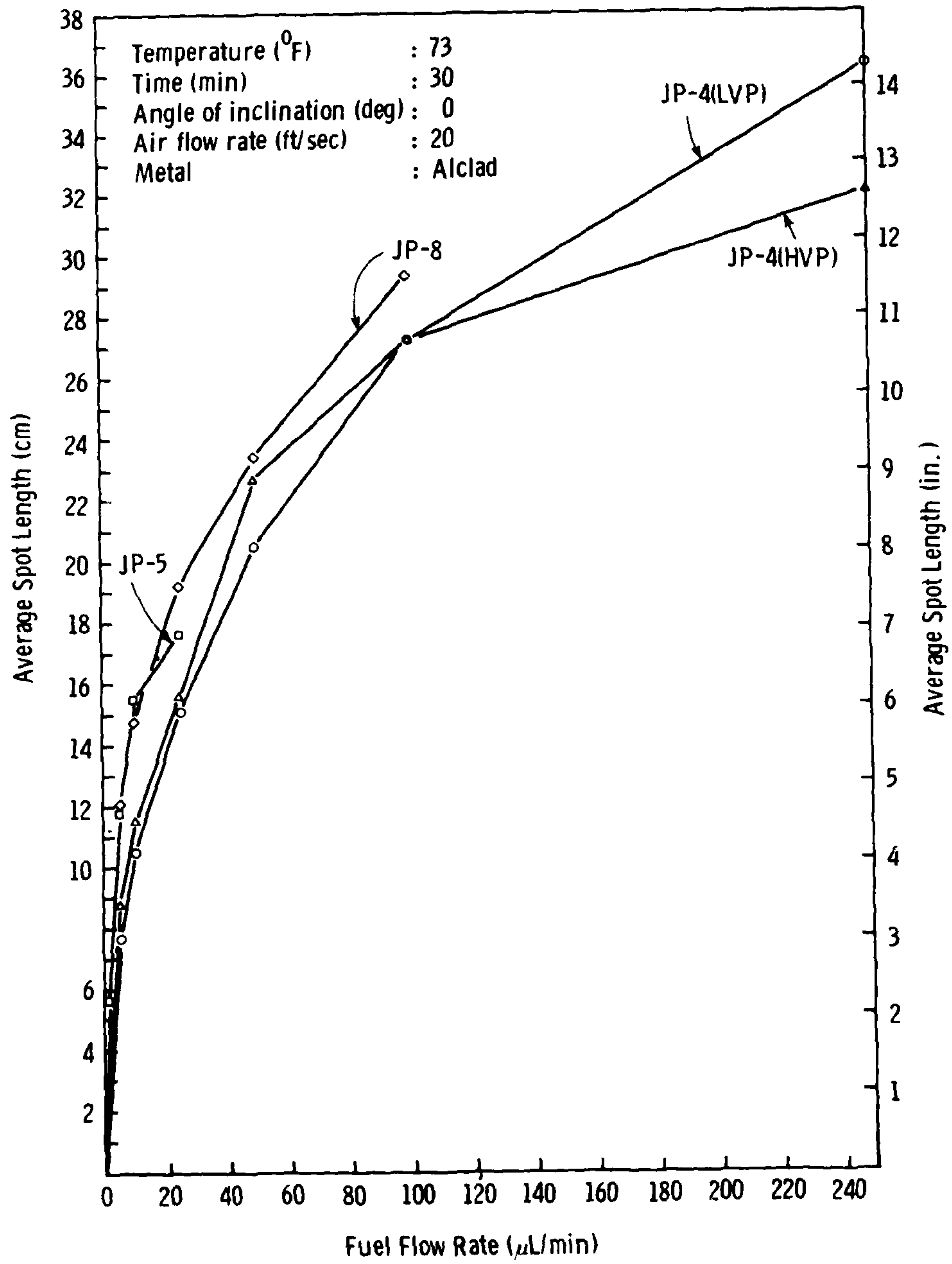



Figure 9. Spot lengths of JP-4(LVP), JP-4(HVP), JP-5 and JP-8 at the end of 30-minute experiments as functions of fuel flow rates.

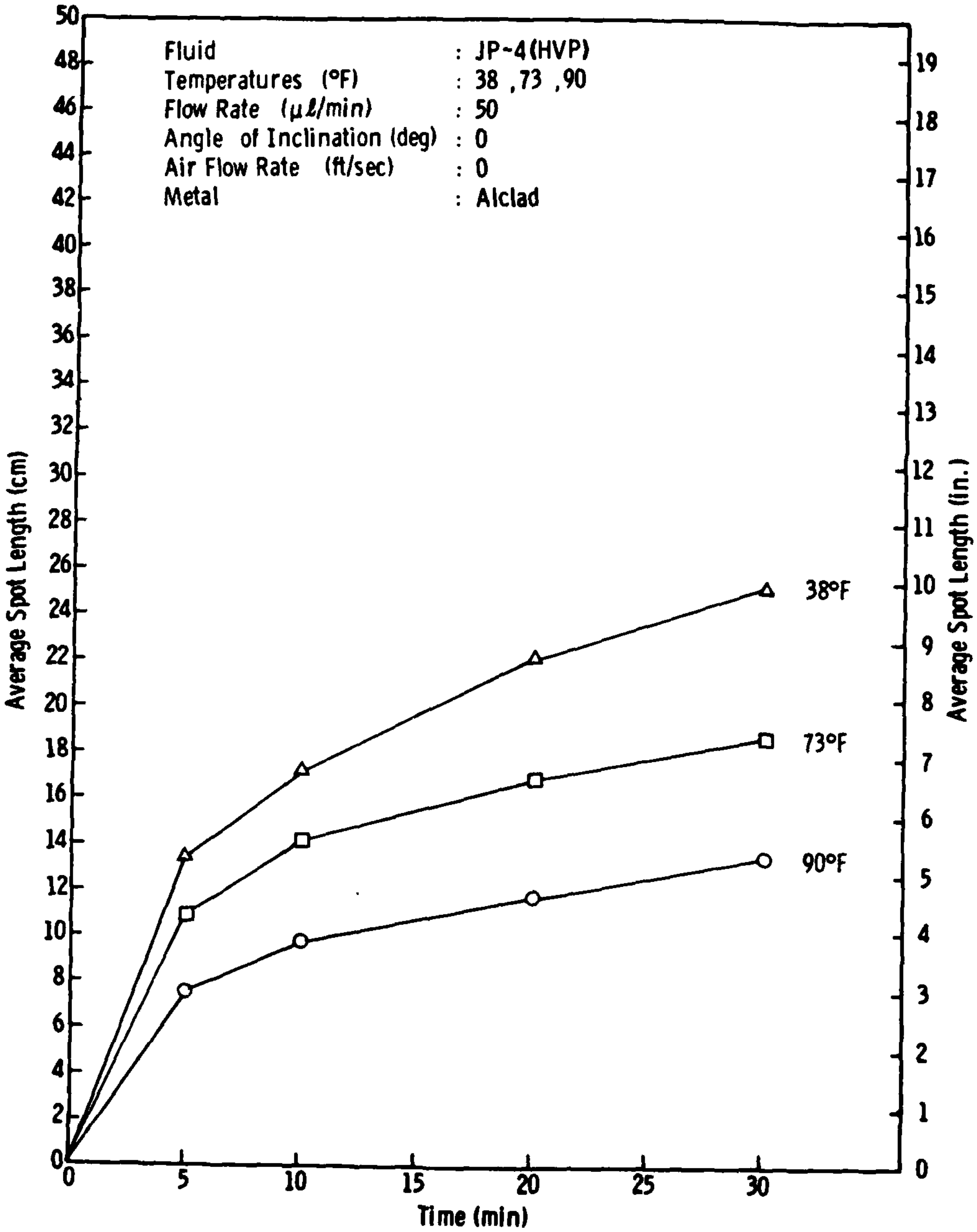



Figure 10. Surface-dispersion of JP-4(HVP) at different temperatures.

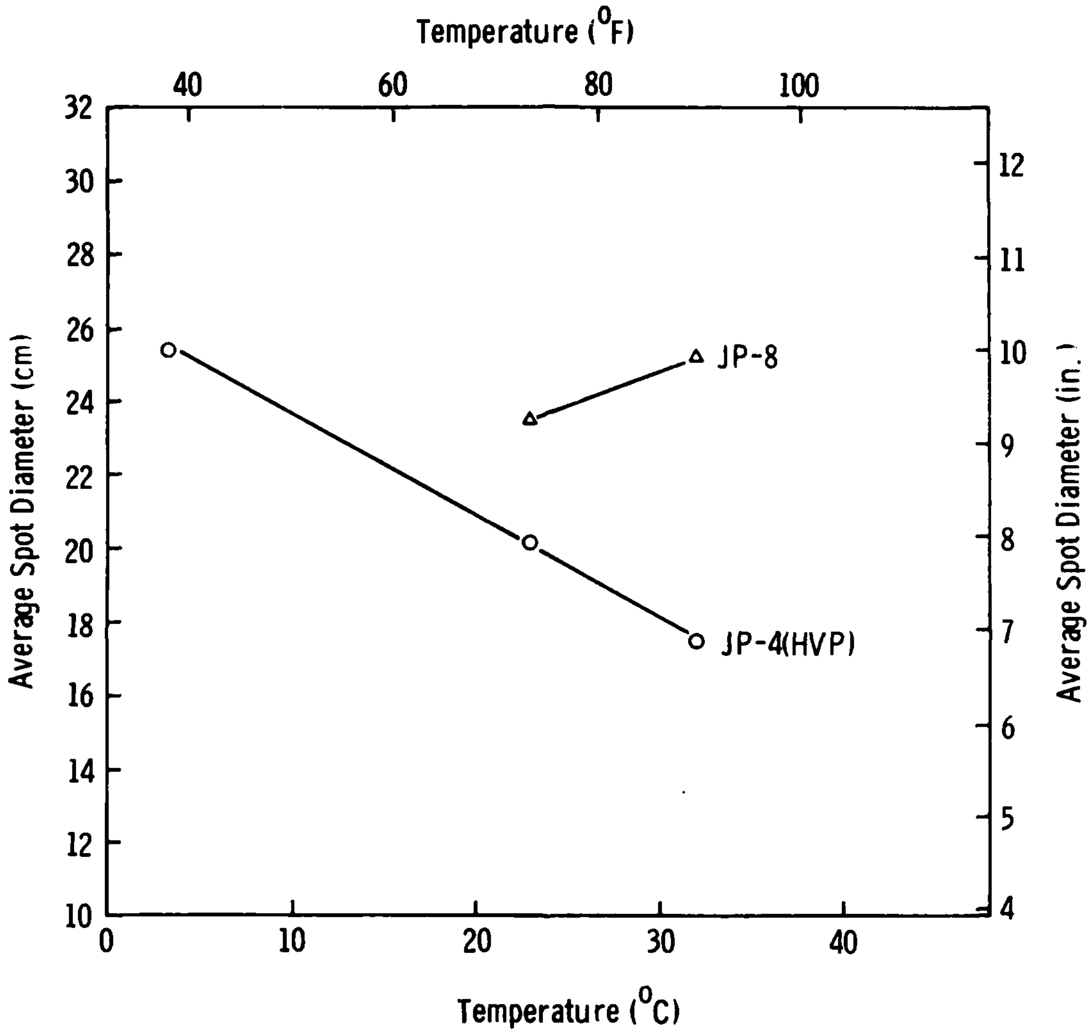



Figure 11. Average spot diameters for JP-4(HVP) and JP-8 as functions of temperature on Alclad surface after 30 minutes in a quiescent atmosphere.

### Effect of Panel Angle of Inclination

The direction of fuel dispersion in an inclined plane appears to be affected mainly by the surface tension and volatility. The fuels of low surface tension and high volatility [JP-4(LVP) and JP-4(HVP)] dispersed in a circular pattern on panel surfaces inclined at 5° and 10°, at flow rates ranging up to 500 μℓ/min. (see Figure 12). At 90° angle of inclination, the surface-dispersion pattern was noncircular when the fuel flow rate was 50 μℓ/min.

JP-5 and JP-8, fuels of lower volatility and higher surface tension than JP-4, dispersed more readily in noncircular pattern than the latter fuel. The dispersion pattern was distinctly noncircular at the fuel flow rate of 100 μℓ/min. when the panel angle of inclination was 5° and 10°.

Dripping of fuels from the panel surface occurred more readily (i.e., at lower flow rates) when they dispersed along inclined panel surfaces (see Table A-15 in the Appendix).

### Effect of Panel Material

The dispersion of fuels on three different material surfaces commonly used for the aircraft integral fuel tanks was investigated. These materials were unclad aluminum alloy, aluminum-clad aluminum alloy (Alclad), and Alclad coated with polyurethane latex paint.

The rates of dispersion of all jet fuels were not significantly affected by the surface they contacted (see Figure 13). However, dripping occurred more readily from the surface coated with the polyurethane latex paint (see Table A-15 in the Appendix).

## MINIMUM FUEL FLOW RATES AT WHICH SUSTAINED BURNING OCCURRED

The leakage of fuel at a rate sufficiently rapid to support sustained burning could be potentially very hazardous. However, for the assessment of hazard associated with leakage, it is essential to know these leakage rates as functions of temperature for the fuels of interest. Experimental measurements were conducted with the following seven fuels and fuel mixtures to determine the flow rates at which they supported sustained burning: AvGas, JP-4(HVP), JP-4(LVP), JP-5, JP-8, JP-4(HVP)/JP-8 (10/90), and JP-4/JP-8 (50/50). The data are summarized in Figure 14, and Table A-17 in the Appendix.

Since the heats of combustion of the fuels used in this work do not differ greatly, the differences of minimum flow rates required for sustained burning are caused mainly by their volatilities. The very volatile fuels [i.e., AvGas and JP-4(HVP)] burned in a sustained manner when leaking at flow rates ranging from 0.2 to 0.7 mℓ/min. through the orifice. In contrast, the least volatile fuel,

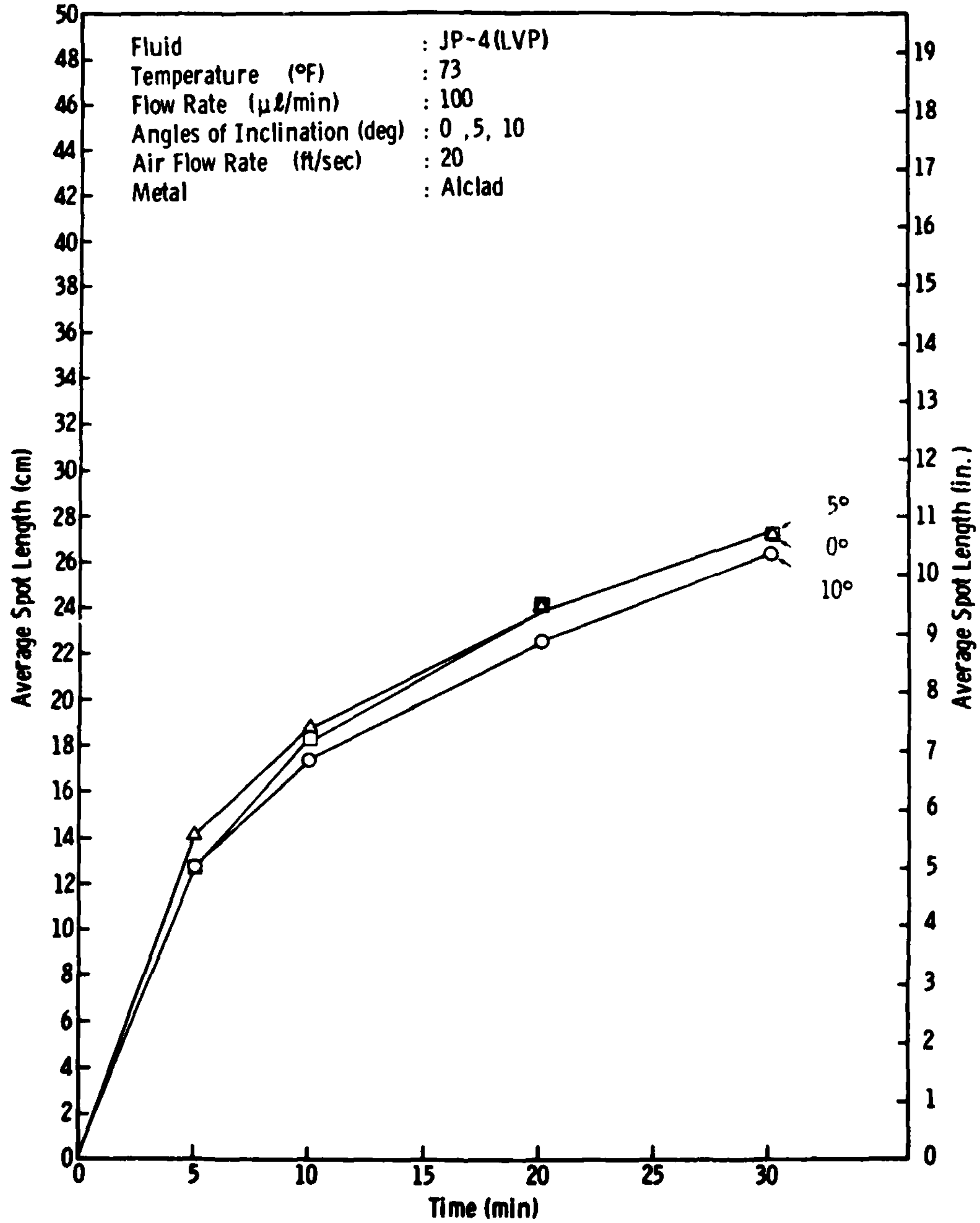



Figure 12. Surface-dispersion of JP-4(LVP) at 0°, 5° and 10° angles of panel inclination.

3

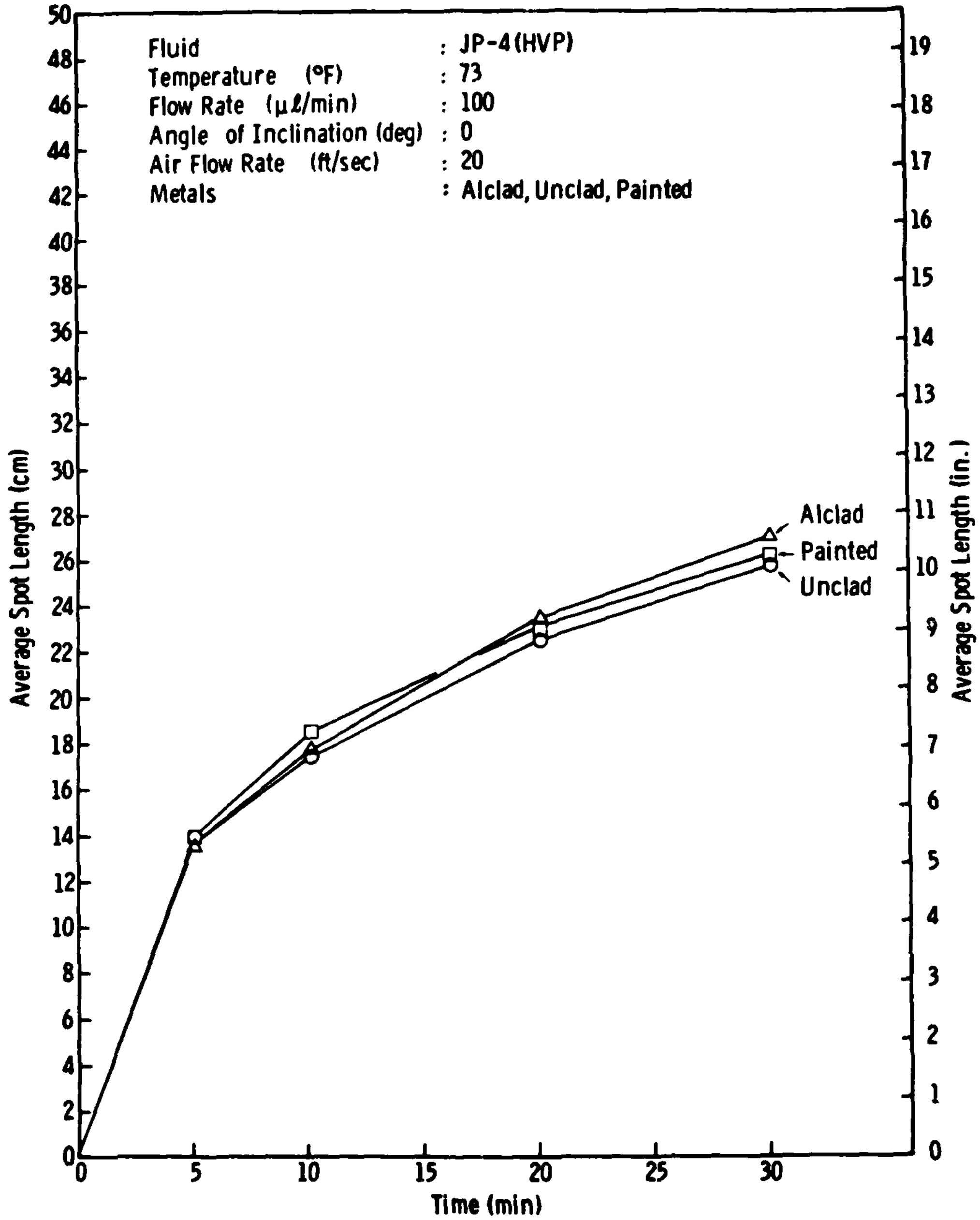



Figure 13. Rates of surface-dispersion of JP-4(HVP) on Alclad, unclad aluminum alloy and polyurethane latex-coated surfaces.

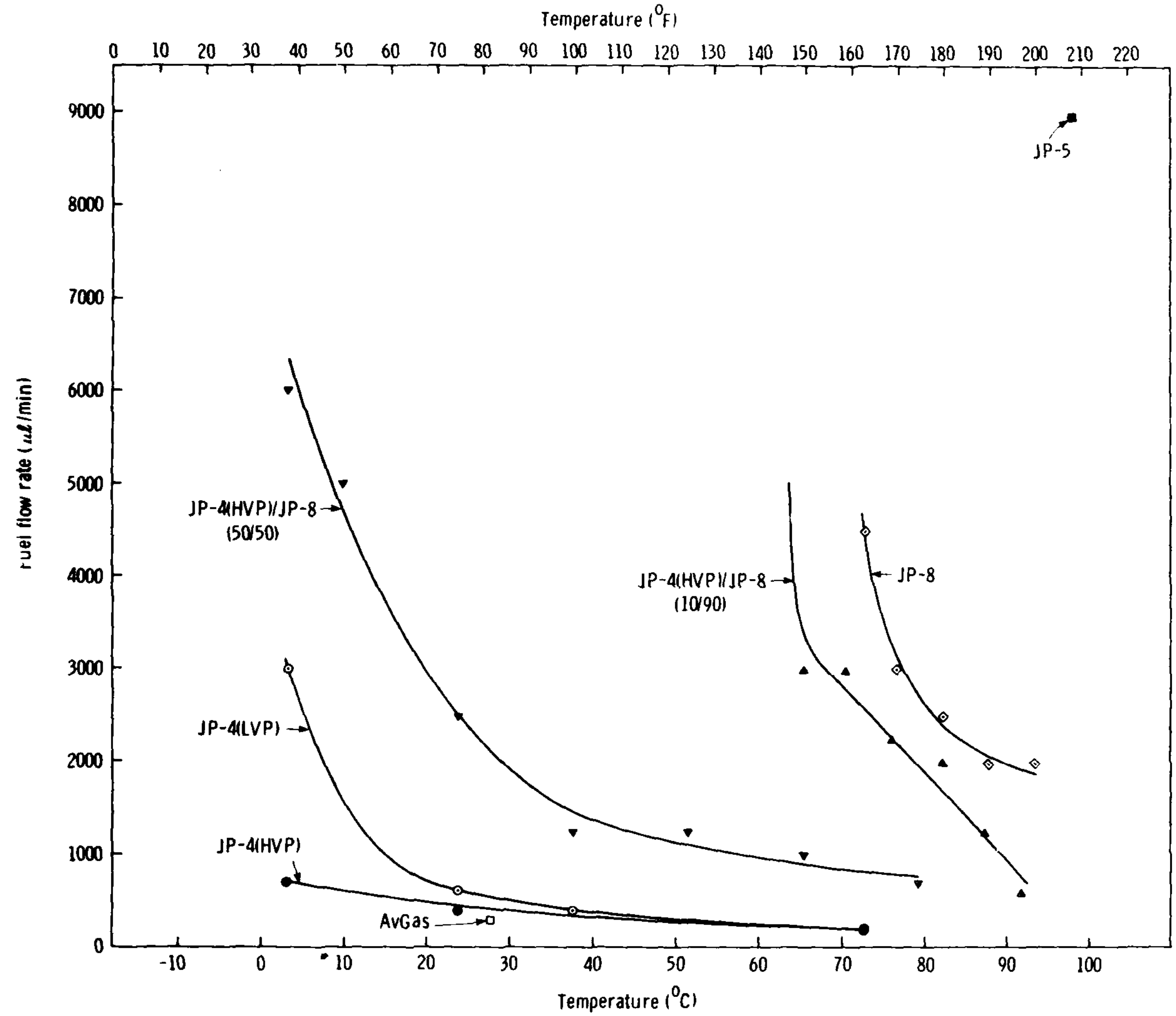



Figure 14. Minimum fuel flow rates at which sustained burning occurred.

JP-5, did not burn in a sustained manner until its flow rate had been increased to the unexpectedly high value of 9 mℓ/min. To achieve sustained burning even at this flow rate, the fuel and the surface had to be heated to 98°C (208°F).

In the event of integral fuel tank leakage, during normal operation of the aircraft, the conditions are not very conducive for ignition and sustained burning, especially with fuels of low vapor pressure at the ambient temperature. The fuel tank surface functions as a large heat sink, in intimate contact with the dispersing fuel film.

## PROPOSED INTEGRAL FUEL TANK EXTERNAL LEAK CLASSIFICATION CRITERIA

Assessment of the fuel leak results and the ignition, flame spread and sustained burning properties of the various aircraft fuels indicates that favorable revision to the Air Force Technical Order 1-1-3 integral fuel tank external leak classification criteria is appropriate without any compromise of operational safety. In view of the differences between the types of fuel with respect to leak pattern versus leak rate manifestations, as well as in the fire threat, it is also apparent that any meaningful fuel leak classification criteria must be formulated on the basis of the specific fuel being utilized.

The revised criteria (see Table 3) that are proposed below classify fuels into three basic categories: the high volatility fuels such as AvGas, the intermediate volatility fuels such as JP-4 and mixtures of JP-4 with lower volatility fuels such as JP-8 and JP-5 (Note: JP-4 for this purpose is equivalent to civil airline Jet B fuel); and the lower volatility fuels such as JP-8 and JP-5 fuels (Note: the civil airline Jet A and Jet A-1 fuel designations for leak hazard purposes are considered equivalent to JP-8).

In arriving at the revised criteria, the following overall facts or trends were given principal consideration:

(1) A relatively small leak rate or overall very small volume of fuel is required to exhibit a leak spot of significant size, length or area. For example, Figure 8 [data for specification, high vapor pressure (HVP), JP-4 fuel] indicates that a leak rate of 25 microliters/minute or 0.025 milliliter/minute (0.025 fluid ounce/per hour) yields a spot length of 6 inches in 30 minutes.

(2) In general, the lower volatility fuels such as JP-8 and JP-5 are much more prone to exhibit dripping, particularly at leak rates in excess of 100 microliters/minute. The tendency to drip becomes more pronounced at lower ambient temperatures. At leak rates below that necessary for dripping to occur, the low volatility fuels such as JP-8 and JP-5 generally exhibit a larger spot length or area than either JP-4 or AvGas.

TABLE 3. PROPOSED AIRCRAFT INTEGRAL FUEL TANK EXTERNAL LEAK CLASSIFICATION CRITERIA

| Leak category | Fuel type[a] High volatility (AvGas) | Intermediate volatility (JP-4, JP-4/low volatility fuel mixtures) | Low volatility (JP-8, JP-5) |
|---|---|---|---|
| Class A (stain) | 1/4 | 1/4 | 1/4 |
| Class B (slow seep) | 3/4 | 3/4 | 3/4 |
| Class C (weep) | 2 1/2 Without dripping | 6 Without dripping | 8 and/or 4 drops/minute |
| Class D (running leak) | Greater than 2 1/2 or drips or runs from surface | Greater than 6 or drips or runs from surface | Greater than 8 or 4 drops/ minute |

[a]All values represent maximum fuel spot size (length or diameter) in inches or condition after 6 minutes of observation starting with a freshly dried surface.

(3) For leak rates below those required for the onset of dripping, the test data indicate that in general the spot length manifested in 6 minutes will be approximately half that manifested in 30 minutes, regardless of the fuel type.

(4) Figure 14 indicates the fire threat or sustained burning hazard associated with a given leak rate and the type of fuel involved. The data confirm the anticipated fire threat trend or vulnerability as influenced by fuel volatility. In general, the more volatile fuels such as AvGas and JP-4 are more prone to ignition and sustained burning. In addition, depending upon the temperature, a certain minimum fuel leakage rate must be exceeded for each fuel to transition from a flash to sustained fire condition. Even in the latter case, the magnitude of the fire is very small. It should also be noted that the propane flame ignition source utilized in these tests represents a relatively severe ignition threat compared to that which would be encountered in typical ground operations. The latter would more likely be of the static electricity or friction spark type ignition source. In establishing acceptable external leak criteria, the aircraft operational envelope and the effects of fuel migration/interaction with on-board equipment subsystems must also be

considered. In the case of the JP-4 fuel, the leak rates required for sustained burning obtained here are in good qualitative agreement with the fuel liquid regression rates for diffusive burning of gasoline in open pans of various diameters (1 cm to 300 cm diameter range) given in Reference 11. For small pan diameters (1-2 cm), fuel feed rates of approximately 500 $\mu\ell$/minute or 0.5 ml/minute are indicated as required for sustained burning to occur. In our tests, under different configuration conditions, depending upon environmental temperature, leakage rates of 200 to 700 $\mu\ell$/minute were required for sustained burning to occur. Accordingly, allowable leak rates for JP-4 should be kept below 200 $\mu\ell$/minute to minimize the possibility of any localized, sustained fire occurring at the point of leakage.

For lower volatility fuels, such as JP-8 and JP-5, the agreement between our fuel feed rates for sustained burning versus those of Reference 11 is poor. Where our data for JP-8 indicate no ignition at ambient temperatures and 2000 $\mu\ell$/minute (2 ml/minute) leak rate requirement at elevated temperature (208°F), Reference 11 for the equilibrium diffusive pool burning condition of diesel fuel in the 1-2 cm diameter pan condition indicates a minimal fuel feed rate requirement of 200 to 300 $\mu\ell$/minute. The difference in magnitude is attributable to fuel ignitibility and flame attitude/geometry factors. For maximum safety, it is considered that a leak rate in excess of 200 $\mu\ell$/minute should not be permitted with the lower volatility (JP-8, JP-5) fuels.

As a consequence of the aforementioned considerations, the suggested revised leak criteria for incorporation into Air Force Technical Order 1-1-3 are delineated in Table 3.

Basically, we have converted all requirements into a common 6 minute inspection interval. The Class A and Class B categories are principally of interest for classifying leaks within dry bays or other partially enclosed areas. Since no effort has yet been conducted to distinguish significant differences between fuels with regards to compartment fire and explosion hazards, the spot length values currently indicated in T. O. 1-1-3 have been maintained, however, on the basis of a six (6) minute rather than a thirty minute inspection period. The Class C and Class D leak categories are principally of interest for classifying external fuel leaks. The criteria are based on the six (6) minute inspection interval and varying depending on the fuel involved. Any external leaks exceeding Class C criteria require immediate repair action. For the high and intermediate volatility fuels the critical leak criteria are those associated with a 100 microliters per minute leak rate or approximately one-half the leak rate required for sustained burning of JP-4 at 163°F (see Figure 14). In the case of the lower volatility fuels, such as JP-8, the critical leak patterns are those associated with a 200 microliters per minute (4 drops per minute) leak rate or below (see Figure 9). As indicated by the test data, the lower volatility

fuels will exhibit dripping more often than not. As also noted in Figure 14, even at the two microliters per minute leak rate, a large safety factor with respect to the leak rate required for sustained burning still exists. In view of the greater likelihood of low volatility fuels to run and accumulate, any relaxation beyond the 4 drops per minute drip rate is not recommended. The criteria offered are for single leak conditions only. Extension of these criteria to multiple leak scenarios, by allowing for proper distance requirements between leaks, should be defined by AFLC and AFSC/ASD fuel system engineering personnel.

## CONCLUSIONS

1. The dispersing fuel films are very thin (<0.05 mm/0.002 in. thick). Therefore, fuels leaking at low rates cover significant-sized areas. For example, JP-4(LVP), leaking at the rate of 25 $\mu\ell$/min. (0.051 fl oz/hr) develops a spot of 15 cm (6 in.) diameter in 30 minutes (Ref. Fig. 6).

2. Fuels of low volatility (i.e., JP-5 and JP-8) disperse at faster rates over the surface than those of high volatility (i.e., AvGas and JP-4), at leakage rates at which dripping does not occur (Ref. Fig. 9).

3. Fuels exhibit great differences in their propensity for dripping. Those of low volatility drip much more readily upon leakage than those of high volatility from both horizontal and inclined surfaces.

4. The tendency of fuels to drip becomes greater at lower ambient temperatures.

5. Air flow at the speed of 21.9 km/hr (13.6 miles/hr) has no significant effect on surface-dispersion of fuel.

6. Dripping of leaking fuels occurs more readily from inclined than from horizontal surfaces.

7. The rates of surface-dispersion of fuels are identical on unclad aluminum alloy, Alclad, and polyurethane latex-coated surfaces. However, dripping occurs at lower leakage rates from the latter surface than from the bare metal surfaces.

8. The potential hazards arising from sustained burning are greater with volatile fuels (i.e., AvGas and JP-4) than those of low volatility (i.e., JP-5 and JP-8). Each fuel, at any temperature, must leak at a minimal rate to support sustained burning at the leakage site; only flashing (i.e., transitory burning) occurs at lower leakage rates.

9. Relaxation of the current AF Technical Order 1-1-3 integral fuel tank external leak classification criteria in accordance with the proposed revised criteria indicated in Table 3 is feasible without any compromise of operational safety.

## RECOMMENDATIONS

It is recommended that the proposed revised integral fuel tank external leak classification criteria be evaluated by AFSC (ASD), AFLC (AFALD), AFISC/IG and Air Force operating commands for near-term incorporation into Air Force Technical Order 1-1-3. Results of this program should also be furnished to the other Military Services and Civil Aviation authorities for possible United States and International standardization of the leak classification criteria utilized.

APPENDIX I

DATA TABULATIONS

A. Properties of Fuels

## TABLE 4. DENSITIES, KINEMATIC VISCOSITIES AND VAPOR PRESSURES OF JET FUELS

| Physical property | Determined value | | | |
|---|---|---|---|---|
| | JP-4(LVP) | JP-4(HVP) | JP-5 | JP-8 |
| Density (g/cm$^3$) | | | | |
| at 0°C (32°F) | 0.7693 | 0.7805 | 0.8231 | 0.8169 |
| at 25.0°C (77°F) | 0.7489 | 0.7595 | 0.8050 | 0.7982 |
| at 37.8°C (100°F) | 0.7387 | 0.7493 | 0.7956 | 0.7888 |
| Kinematic viscosity (centistokes) | | | | |
| at -17.8°C (0°F) | 1.577 | 1.459 | 5.913 | 4.468 |
| at 25°C (77°F) | 0.8489 | 0.8053 | 2.032 | 1.715 |
| at 37.8°C (100°F) | 0.7369 | 0.7022 | 1.636 | 1.405 |
| Surface tension (dynes/cm) | | | | |
| at 0°C (32°F) | 24.56 | 24.93 | 28.22 | 28.18 |
| at 21.1°C (70°F) | 22.66 | 22.88 | 26.44 | 26.17 |
| at 37.8°C (100°F) | 21.18 | 21.26 | 25.04 | 24.62 |
| Vapor pressure (torr) | | | | |
| at 0°C (32°F) | 27.0 | 37.0 | 4.4 | 4.7 |
| at 21.1°C (70°F) | 63.5 | 87.5 | 8.5 | 10.4 |
| at 37.8°C (100°F) | 117.5 | 158.0 | 13.4 | 18.0 |

## TABLE 5. FLASH AND FIRE POINTS OF JET FUELS

| Fuel | Flash point (°C) | Flash point (°F) | Fire point (°C) | Fire point (°F) |
|---|---|---|---|---|
| JP-4 (LVP) | -3.5 | 25.7 | 1.0 | 33.8 |
| JP-4 (HVP) | -9.0 | 15.8 | -6.5 | 20.3 |
| JP-5 | 56.2 | 133.2[a] | 62.1 | 143.8 |
| JP-8 | 40.7 | 105.3[b] | 45.3 | 113.5 |

[a] Mr. W. Crawford of the Air Force Aero Propulsion Laboratory reported a flash point of 56.7°C (134°F) for this sample of JP-5 fuel.

[b] A flash point of 42.2°C (108°F) was reported by Mr. W. Crawford for this sample of JP-8 fuel.

TABLE 6. SIMULATED DISTILLATION OF JET FUEL SAMPLES

| Sample recovered (%) | Temperature (°C) | | | | Temperature (°F) | | | |
|---|---|---|---|---|---|---|---|---|
| | JP-4(LVP) | JP-4(HVP) | JP-5 | JP-8 | JP-4(LVP) | JP-4(HVP) | JP-5 | JP-8 |
| 0.5 | 27 | 23 | 109 | 92 | 81 | 73 | 228 | 198 |
| 1 | 34 | 25 | 126 | 103 | 93 | 77 | 259 | 217 |
| 5 | 60 | 56 | 163 | 137 | 140 | 133 | 325 | 279 |
| 10 | 76 | 70 | 173 | 159 | 169 | 158 | 343 | 318 |
| 20 | 98 | 93 | 188 | 177 | 208 | 199 | 370 | 351 |
| 30 | 116 | 111 | 199 | 188 | 241 | 232 | 390 | 370 |
| 40 | 133 | 126 | 210 | 198 | 271 | 259 | 410 | 388 |
| 50 | 147 | 143 | 220 | 207 | 297 | 289 | 428 | 405 |
| 60 | 164 | 161 | 229 | 216 | 327 | 322 | 444 | 421 |
| 70 | 178 | 179 | 240 | 226 | 352 | 354 | 464 | 439 |
| 80 | 195 | 204 | 250 | 239 | 383 | 399 | 482 | 462 |
| 90 | 215 | 229 | 265 | 256 | 419 | 444 | 509 | 493 |
| 95 | 229 | 245 | 275 | 267 | 444 | 473 | 527 | 513 |
| 99 | 252 | 264 | 290 | 290 | 486 | 507 | 554 | 554 |
| 99.5 | 266 | 275 | 311 | 298 | 551 | 527 | 592 | 568 |

TABLE 7. MOLECULAR DISTRIBUTION IN JET FUELS ESTABLISHED BY SIMULATED DISTILLATION

| Carbon atom number | Weight percent JP-4(LVP) | JP-4(HVP) | JP-5 | JP-8 |
|---|---|---|---|---|
| $C_3 - C_4$ | <0.1 | <0.1 | | <0.1 |
| $C_4 - C_5$ | 2.6 | 4.2 | | 0.1 |
| $C_5 - C_6$ | 7.7 | 7.7 | 0.1 | 0.2 |
| $C_6 - C_7$ | 13.6 | 14.7 | 0.2 | 0.9 |
| $C_7 - C_8$ | 14.7 | 14.8 | 0.5 | 2.5 |
| $C_8 - C_9$ | 14.2 | 13.9 | 1.4 | 4.5 |
| $C_9 - C_{10}$ | 12.9 | 10.9 | 4.8 | 7.8 |
| $C_{10} - C_{11}$ | 11.9 | 8.8 | 14.3 | 16.6 |
| $C_{11} - C_{12}$ | 10.1 | 7.6 | 18.3 | 21.6 |
| $C_{12} - C_{13}$ | 7.0 | 7.0 | 19.2 | 18.3 |
| $C_{13} - C_{14}$ | 3.3 | 5.7 | 15.5 | 12.3 |
| $C_{14} - C_{15}$ | 1.0 | 3.0 | 13.9 | 8.0 |
| $C_{15} - C_{16}$ | 0.6 | 1.0 | 7.9 | 4.3 |
| $C_{16} - C_{17}$ | 0.1 | 0.3 | 3.0 | 2.2 |
| $C_{17} - C_{18}$ | 0.1 | 0.1 | 0.6 | 0.4 |
| $C_{18} - C_{19}$ | 0.1 | 0.1 | 0.3 | 0.2 |

## B. Surface Dispersion of Fuels

1. Key to Tables
2. Tables

# KEY TO TABLES CONTAINING SURFACE-DISPERSION DATA FOR FUELS[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (µℓ/min.) / Fluid | 3.3 °C (38°F) None JP-4 (HVP)[b] | JP-5 | JP-8 | 23 °C (73°F) (20 ft/sec) JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | 23 °C (73°F) None JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | 32 °C (90°F) None JP-4 (HVP) | JP-5 | JP-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Table A-6 | | | | Table A-9 | | | | | Table A-11 | |
| 0 | 1 | | | | | | • | | | | | | | | | |
| 0 | 5 | | Table A-5 | | • | • | • | • | • | | • | | | | | |
| 0 | 10 | | • | | • | • | • | • | • | • | • | | | | • | |
| 0 | 25 | | • | • | • | • | • | • | • | • | • | | | | • | |
| 0 | 50 | • | • | • | • | • | • | • | • | • | • | • | | • | • | • |
| 0 | 100 | • | | • | • | • | • | • | | | • | • | • | • | | • |
| 0 | 250 | | | • | • | • | • | • | | | • | | • | | | |
| 0 | 500 | | | | • | • | | • | • | | | | • | | | |
| 0 | 1000 | | | | • | • | | | • | | | | • | | | |
| 0 | 1400 | | | | | | | | | | | | • | | | |
| | | | | | | Table A-7 | | | | | | | | | | |
| 5 | 10 | | | | • | • | • | • | | | | | | | | |
| 5 | 100 | | | | • | • | • | • | | | | | | | | |
| 5 | 250 | | | | • | • | | • | | | | | | | | |
| 5 | 500 | | | | • | • | | | | | | | | | | |
| | | | | | | Table A-8 | | | | | | | | | | |
| 10 | 10 | | | | • | • | • | • | | | | | | | | |
| 10 | 100 | | | | • | • | • | • | | | | | | | | |
| 10 | 250 | | | | • | • | | | | | | | | | | |
| 10 | 500 | | | | • | • | | | | | | | | | | |
| | | | | | | | | | | Table A-10 | | | | | | |
| 90 | 5 | | | | | | | | | | • | | | | | |
| 90 | 10 | | | | | | | | • | | • | | | | | |
| 90 | 50 | | | | | | | | • | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table

[b] High vapor pressure sample

[c] Low vapor pressure sample

[d] JP-4/JP-8 in 10/90 volume ratio

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

KEY TO TABLES CONTAINING SURFACE-DISPERSION DATA FOR FUELS (continued)[a]

| Angle (deg) | Fuel flow rate ($\mu\ell$/min.) | Measurement time (min.) | Fluid JP-4 (LVP) | Fluid JP-4 (HVP) | Fluid JP-5 | Fluid JP-8 | Remarks |
|---|---|---|---|---|---|---|---|
| 0 | 10 | 180 | | Table A-12 | ● | | Extended measurement time Alclad surface |
| 10 | 100 | 30 | | ● | | ● | Longer flow distance Alclad surface |
| 10 | 500 | 30 | | ● | | ● | Longer flow distance Alclad surface |
| 0 | 10 | 30 | Table A-13 | | ● | ● | Painted surface [b] |
| 0 | 25 | 30 | | | ● | ● | Painted surface [b] |
| 0 | 50 | 30 | | | ● | ● | Painted surface [b] |
| 0 | 100 | 30 | ● | ● | ● | ● | Painted surface [b] |
| 0 | 250 | 30 | ● | ● | | | Painted surface [b] |
| 0 | 500 | 30 | ● | ● | | | Painted surface [b] |
| 0 | 100 | 30 | ● Table A-14 | ● | ● | ● | Unclad surface |

[a] All experiments shown in this table were conducted at 23 °C(73 °F), at an air flow rate of 6.1 m/sec(20 ft/sec)

[b] Polyurethane latex coating

TABLE 8. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 3.3°C (38°F). QUIESCENT ATMOSPHERE. ANGLE OF INCLINATION 0 DEGREE

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (HVP) | 50 | 5 | 13.2 ± 2.0 | 13.2 ± 2.0 | 138 |
| " | 50 | 10 | 17.0 ± 1.3 | 17.1 ± 1.4 | 228 |
| " | 50 | 20 | 22.0 ± 0.9 | 22.2 ± 0.7 | 383 |
| " | 50 | 30 | 25.1 ± 1.3 | 25.7 ± 0.8 | 505 |
| JP-4 (HVP) | 100 | 5 | 14.2 ± 0.6 | 14.4 ± 0.3 | 160 |
| " | 100 | 10 | 19.2 ± 1.0 | 19.0 ± 0.0 | 286 |
| " | 100 | 20 | 24.3 ± 0.6 | 24.8 ± 0.8 | 475 |
| " | 100 | 30 | 28.0 ± 0.9 | 28.7 ± 0.8 | 631 |
| JP-5 | 10 | 5 | 5.0 ± 0.0 | 5.3 ± 0.5 | 21 |
| " | 10 | 10 | 7.6 ± 0.6 | 7.6 ± 0.6 | 45 |
| " | 10 | 20 | 11.0 ± 1.2 | 11.0 ± 1.3 | 95 |
| " | 10 | 30 | 13.5 ± 1.7 | 13.8 ± 2.5 | 147 |
| JP-5 | 25 | 5 | 5.5 ± 0.5 | 5.5 ± 0.5 | 24 |
| " | 25 | 10 | 8.4 ± 0.8 | 8.5 ± 0.9 | 56 |
| " | 25 | 20 | 12.0 ± 1.0 | 11.3 ± 1.5 | 107 |
| " | 25 | 30 | 16.2 ± 1.0 | 14.7 ± 2.5 | 186 |
| JP-5 | 50 | 5 | 3.6 ± 0.9 | 3.6 ± 0.9 | 10 |
| " | 50 | 10 | 6.2 ± 0.3 | 6.6 ± 0.4 | 32 |
| " | 50 | 20 | 9.6 ± 0.4 | 9.7 ± 0.6 | 73 |
| " | 50 | 30 | 12.5 ± 0.5 | 12.7 ± 0.6 | 125 |
| JP-8 | 25 | 5 | 6.7 ± 0.3 | 6.7 ± 0.3 | 35 |
| " | 25 | 10 | 9.8 ± 0.3 | 9.8 ± 0.3 | 76 |
| " | 25 | 20 | 14.8 ± 1.0 | 14.8 ± 1.0 | 172 |
| " | 25 | 30 | 17.6 ± 0.4 | 17.9 ± 1.0 | 247 |
| JP-8 | 50 | 5 | 5.9 ± 0.5 | 5.7 ± 0.3 | 26 |
| " | 50 | 10 | 9.3 ± 0.3 | 9.0 ± 0.0 | 66 |
| " | 50 | 20 | 13.5 ± 0.9 | 14.0 ± 2.2 | 149 |
| " | 50 | 30 | 16.4 ± 1.4 | 17.0 ± 2.6 | 219 |
| JP-8 | 100 | 5 | 5.4 ± 0.4 | 5.4 ± 0.4 | 23 |
| " | 100 | 10 | 7.3 ± 1.3 | 7.3 ± 1.3 | 42 |
| " | 100 | 20 | 9.6 ± 2.1 | 11.0 ± 2.2 | 83 |
| " | 100 | 30 | 13.1 ± 2.7 | 13.3 ± 2.9 | 137 |
| JP-8 | 250 | 5 | 6.2 ± 0.8 | 6.2 ± 0.8 | 30 |
| " | 250 | 10 | 8.9 ± 1.2 | 9.1 ± 0.9 | 63 |
| " | 250 | 20 | 13.4 ± 1.7 | 13.5 ± 1.5 | 142 |
| " | 250 | 30 | 16.8 ± 2.3 | 17.5 ± 1.8 | 231 |

TABLE 9. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 23°C (73°F). AIR FLOW RATE 6.1 m/sec. ANGLE OF INCLINATION 0 DEGREE

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Spot dimensions (cm) Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (LVP) | 5 | 5 | 4.7 ± 0.3 | 4.8 ± 0.1 | 17 |
| " | 5 | 10 | 5.5 ± 0.3 | 5.8 ± 0.4 | 25 |
| " | 5 | 20 | 6.8 ± 0.2 | 7.5 ± 0.4 | 40 |
| " | 5 | 30 | 7.7 ± 0.1 | 8.3 ± 0.2 | 51 |
| JP-4 (LVP) | 10 | 5 | 5.4 ± 1.0 | 5.7 ± 0.5 | 24 |
| " | 10 | 10 | 7.6 ± 0.5 | 8.0 ± 0.4 | 48 |
| " | 10 | 20 | 9.7 ± 0.3 | 10.3 ± 0.1 | 78 |
| " | 10 | 30 | 10.5 ± 0.1 | 11.0 ± 0.4 | 91 |
| JP-4 (LVP) | 25 | 5 | 8.6 ± 0.4 | 8.9 ± 0.4 | 60 |
| " | 25 | 10 | 10.7 ± 0.4 | 11.4 ± 0.4 | 96 |
| " | 25 | 20 | 13.8 ± 0.5 | 14.3 ± 0.6 | 155 |
| " | 25 | 30 | 15.1 ± 0.4 | 15.2 ± 0.3 | 180 |
| JP-4 (LVP) | 50 | 5 | 11.0 ± 0.0 | 11.2 ± 0.3 | 97 |
| " | 50 | 10 | 14.3 ± 0.6 | 14.6 ± 0.2 | 164 |
| " | 50 | 20 | 18.5 ± 0.5 | 19.0 ± 0.0 | 276 |
| " | 50 | 30 | 20.5 ± 0.5 | 21.7 ± 0.6 | 349 |
| JP-4 (LVP) | 100 | 5 | 14.0 ± 0.8 | 13.7 ± 0.3 | 151 |
| " | 100 | 10 | 18.7 ± 0.3 | 18.9 ± 0.1 | 278 |
| " | 100 | 20 | 23.8 ± 0.4 | 24.0 ± 0.0 | 449 |
| " | 100 | 30 | 27.2 ± 0.4 | 28.2 ± 0.6 | 603 |
| JP-4 (LVP) | 250 | 5 | 19.2 ± 0.6 | 19.6 ± 0.8 | 295 |
| " | 250 | 10 | 25.2 ± 0.7 | 25.3 ± 0.6 | 663 |
| " | 250 | 20 | 32.0 ± 0.0 | 33.5 ± 0.5 | 842 |
| " | 250 | 30 | 36.2 ± 0.8 | 37.7 ± 1.2 | 1070 |
| JP-4 (LVP) | 500 | 5 | 22.8 ± 2.3 | 23.0 ± 2.0 | 412 |
| " | 500 | 10 | 30.8 ± 1.3 | 31.5 ± 1.8 | 763 |
| " | 500 | 20 | 40.0 ± 0.0 | 41.0 ± 0.0 | 1288 |
| " | 500 | 30 | 44.7 ± 0.6 | 44.7 ± 0.6 | 1567 |
| JP-4 (LVP) | 1000 | 5 | 18.5 ± 0.9 | 18.6 ± 0.9 | 270 |
| " | 1000 | 10 | 21.7 ± 0.6 | 22.0 ± 1.0 | 374 |
| " | 1000 | 20 | 26.8 ± 0.8 | 27.5 ± 0.5 | 580 |
| " | 1000 | 30 | 30.0 ± 0.9 | 30.5 ± 0.0 | 719 |

TABLE 9 (continued)

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (HVP) | 5 | 5 | 4.3 ± 1.3 | 3.5 ± 0.9 | 12 |
| " | 5 | 10 | 5.9 ± 0.8 | 5.0 ± 0.5 | 23 |
| " | 5 | 20 | 7.9 ± 0.1 | 6.3 ± 0.6 | 39 |
| " | 5 | 30 | 8.8 ± 0.2 | 7.1 ± 0.6 | 49 |
| JP-4 (HVP) | 10 | 5 | 6.0 ± 1.0 | 5.8 ± 0.8 | 27 |
| " | 10 | 10 | 8.0 ± 0.4 | 7.0 ± 0.5 | 44 |
| " | 10 | 20 | 10.4 ± 0.2 | 9.5 ± 1.0 | 78 |
| " | 10 | 30 | 11.5 ± 0.5 | 9.7 ± 0.6 | 88 |
| JP-4 (HVP) | 25 | 5 | 8.6 ± 0.5 | 8.0 ± 0.5 | 54 |
| " | 25 | 10 | 11.0 ± 0.2 | 10.3 ± 0.3 | 89 |
| " | 25 | 20 | 14.5 ± 0.5 | 12.6 ± 0.4 | 143 |
| " | 25 | 30 | 15.6 ± 1.1 | 14.1 ± 0.5 | 173 |
| JP-4 (HVP) | 50 | 5 | 10.3 ± 2.1 | 10.0 ± 2.0 | 81 |
| " | 50 | 10 | 14.3 ± 1.5 | 12.7 ± 0.8 | 143 |
| " | 50 | 20 | 18.9 ± 0.1 | 17.3 ± 1.0 | 257 |
| " | 50 | 30 | 22.7 ± 2.1 | 19.3 ± 0.6 | 344 |
| JP-4 (HVP) | 100 | 5 | 13.7 ± 0.6 | 13.2 ± 0.6 | 141 |
| " | 100 | 10 | 17.8 ± 0.8 | 16.3 ± 0.6 | 229 |
| " | 100 | 20 | 23.7 ± 0.6 | 22.3 ± 0.3 | 415 |
| " | 100 | 30 | 27.2 ± 1.1 | 25.4 ± 0.4 | 543 |
| JP-4 (HVP) | 250 | 5 | 19.2 ± 1.0 | 18.5 ± 1.5 | 278 |
| " | 250 | 10 | 25.3 ± 1.5 | 24.2 ± 1.0 | 481 |
| " | 250 | 20 | 30.3 ± 0.6 | 28.8 ± 0.8 | 687 |
| " | 250 | 30 | 32.0 ± 0.0 | 31.3 ± 1.2 | 787 |
| JP-4 (HVP) | 500 | 5 | 21.8 ± 1.9 | 22.0 ± 1.0 | 377 |
| " | 500 | 10 | 30.7 ± 2.3 | 31.2 ± 2.4 | 751 |
| " | 500 | 20 | 35.3 ± 2.1 | 38.0 ± 1.7 | 1054 |
| " | 500 | 30 | 37.3 ± 1.5 | 40.3 ± 3.1 | 1182 |
| JP-4 (HVP) | 1000 | 5 | 19.0 ± 3.8 | 21.2 ± 1.3 | 316 |
| " | 1000 | 10 | 23.5 ± 2.8 | 29.0 ± 1.3 | 535 |
| " | 1000 | 20 | 30.3 ± 4.7 | 39.0 ± 2.6 | 929 |
| " | 1000 | 30 | 36.0 ± 6.2 | 43.7 ± 2.3 | 1235 |
| JP-5 | 1 | 5 | 3.7 ± 0.6 | 3.7 ± 0.5 | 11 |
| " | 1 | 10 | 4.5 ± 0.9 | 4.8 ± 0.5 | 17 |
| " | 1 | 20 | 5.1 ± 1.2 | 5.9 ± 1.1 | 24 |
| " | 1 | 30 | 5.7 ± 0.8 | 6.5 ± 1.3 | 29 |

TABLE 9 (continued)

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-5 | 5 | 5 | 4.0 ± 0.0 | 4.0 ± 0.0 | 13 |
| " | 5 | 10 | 6.5 ± 0.5 | 6.5 ± 0.5 | 33 |
| " | 5 | 20 | 9.7 ± 0.3 | 9.7 ± 0.3 | 74 |
| " | 5 | 30 | 11.8 ± 0.3 | 11.8 ± 0.3 | 110 |
| JP-5 | 10 | 5 | 5.8 ± 1.0 | 5.9 ± 0.8 | 27 |
| " | 10 | 10 | 8.7 ± 1.0 | 8.8 ± 0.8 | 60 |
| " | 10 | 20 | 12.5 ± 1.3 | 13.0 ± 0.9 | 128 |
| " | 10 | 30 | 15.5 ± 0.9 | 15.8 ± 0.3 | 193 |
| JP-5 | 25 | 5 | 6.8 ± 0.6 | 6.8 ± 0.8 | 37 |
| " | 25 | 10 | 10.2 ± 0.3 | 10.2 ± 0.3 | 81 |
| " | 25 | 20 | 14.7 ± 0.6 | 15.0 ± 1.0 | 173 |
| " | 25 | 30 | 17.6 ± 0.7 | 18.3 ± 1.1 | 253 |
| JP-5 | 50 | 5 | 4.5 ± 0.5 | 4.3 ± 0.5 | 15 |
| " | 50 | 10 | 5.7 ± 0.7 | 5.5 ± 0.8 | 25 |
| " | 50 | 20 | 7.3 ± 0.7 | 7.2 ± 0.7 | 44 |
| " | 50 | 30 | 8.7 ± 0.4 | 8.8 ± 0.8 | 59 |
| JP-5 | 100 | 5 | 4.3 ± 0.6 | 4.3 ± 0.6 | 15 |
| " | 100 | 10 | 5.8 ± 0.5 | 5.9 ± 0.3 | 27 |
| " | 100 | 20 | 7.3 ± 0.3 | 7.5 ± 0.1 | 43 |
| " | 100 | 30 | 8.5 ± 0.3 | 8.9 ± 0.2 | 59 |
| JP-5 | 250 | 5 | 4.0 ± 0.4 | 3.8 ± 0.4 | 12 |
| " | 250 | 10 | 5.9 ± 0.3 | 5.3 ± 0.2 | 24 |
| " | 250 | 20 | 8.1 ± 0.3 | 7.2 ± 0.3 | 45 |
| " | 250 | 30 | 9.3 ± 0.3 | 8.4 ± 0.4 | 62 |
| JP-8 | 5 | 5 | 5.0 ± 0.4 | 5.1 ± 0.2 | 20 |
| " | 5 | 10 | 6.8 ± 0.8 | 7.0 ± 0.9 | 38 |
| " | 5 | 20 | 9.9 ± 0.7 | 10.2 ± 0.4 | 80 |
| " | 5 | 30 | 12.0 ± 0.5 | 12.5 ± 0.1 | 118 |
| JP-8 | 10 | 5 | 6.0 ± 0.6 | 6.0 ± 1.0 | 28 |
| " | 10 | 10 | 9.2 ± 1.0 | 9.2 ± 0.8 | 66 |
| " | 10 | 20 | 12.5 ± 0.8 | 12.5 ± 0.3 | 123 |
| " | 10 | 30 | 14.8 ± 0.3 | 14.7 ± 0.5 | 171 |

TABLE 9 (continued)

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-8 | 25 | 5 | 7.5 ± 0.5 | 7.4 ± 0.5 | 44 |
| " | 25 | 10 | 11.3 ± 0.3 | 11.3 ± 0.3 | 101 |
| " | 25 | 20 | 16.1 ± 0.4 | 15.9 ± 0.1 | 201 |
| " | 25 | 30 | 19.2 ± 0.3 | 19.2 ± 0.3 | 290 |
| JP-8 | 50 | 5 | 8.7 ± 1.4 | 9.1 ± 1.0 | 62 |
| " | 50 | 10 | 13.0 ± 1.3 | 13.5 ± 1.8 | 138 |
| " | 50 | 20 | 19.2 ± 0.3 | 20.7 ± 1.2 | 311 |
| " | 50 | 30 | 23.4 ± 1.0 | 24.7 ± 1.4 | 454 |
| JP-8 | 100 | 5 | 16.3 ± 3.8 | 12.8 ± 5.5 | 165 |
| " | 100 | 10 | 20.5 ± 3.3 | 17.3 ± 2.9 | 279 |
| " | 100 | 20 | 24.5 ± 0.5 | 27.3 ± 1.2 | 525 |
| " | 100 | 30 | 29.3 ± 0.8 | 30.8 ± 1.0 | 710 |
| JP-8 | 250 | 5 | 5.8 ± 0.3 | 5.8 ± 0.3 | 27 |
| " | 250 | 10 | 8.2 ± 0.8 | 8.5 ± 0.9 | 54 |
| " | 250 | 20 | 11.3 ± 0.6 | 11.3 ± 0.6 | 101 |
| " | 250 | 30 | 13.0 ± 0.6 | 13.2 ± 0.9 | 135 |
| JP-8 | 500 | 5 | 35.3 ± 3.1 | 7.3 ± 1.2 | 203 |
| " | 500 | 10 | 39.0 ± 1.0 | 13.3 ± 1.5 | 408 |
| " | 500 | 20 | 40.0 ± 1.0 | 16.7 ± 1.2 | 524 |
| " | 500 | 30 | 42.2 ± 1.3 | 21.3 ± 3.1 | 706 |

TABLE 10. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 23°C (73°F). AIR FLOW RATE 6.1 m/sec. ANGLE OF INCLINATION 5 DEGREES

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Spot dimensions (cm) Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (LVP) | 10 | 5 | 5.7 ± 0.5 | 5.9 ± 0.6 | 26 |
| " | 10 | 10 | 7.4 ± 0.3 | 7.6 ± 0.4 | 44 |
| " | 10 | 20 | 9.0 ± 0.0 | 9.3 ± 0.3 | 66 |
| " | 10 | 30 | 10.3 ± 0.3 | 10.9 ± 0.1 | 89 |
| JP-4 (LVP) | 100 | 5 | 12.7 ± 1.2 | 12.7 ± 1.2 | 126 |
| " | 100 | 10 | 17.3 ± 1.0 | 17.7 ± 0.8 | 241 |
| " | 100 | 20 | 22.5 ± 0.9 | 23.0 ± 1.0 | 406 |
| " | 100 | 30 | 26.3 ± 1.3 | 26.9 ± 1.2 | 471 |
| JP-4 (LVP) | 250 | 5 | 20.0 ± 0.9 | 20.3 ± 1.2 | 315 |
| " | 250 | 10 | 25.7 ± 0.8 | 26.2 ± 0.8 | 529 |
| " | 250 | 20 | 33.3 ± 0.6 | 32.7 ± 0.6 | 855 |
| " | 250 | 30 | 38.5 ± 0.5 | 37.7 ± 0.6 | 1140 |
| JP-4 (LVP) | 500 | 5 | 24.8 ± 0.6 | 23.8 ± 1.8 | 465 |
| " | 500 | 10 | 33.7 ± 1.1 | 31.0 ± 1.0 | 821 |
| " | 500 | 20 | 41.4 ± 0.1 | 37.7 ± 0.6 | 1226 |
| " | 500 | 30 | 42.9 ± 0.2 | 38.0 ± 1.0 | 1280 |
| JP-4 (HVP) | 10 | 5 | 6.2 ± 0.7 | 5.3 ± 0.6 | 26 |
| " | 10 | 10 | 8.2 ± 1.0 | 6.5 ± 0.9 | 42 |
| " | 10 | 20 | 10.9 ± 0.1 | 8.7 ± 1.5 | 75 |
| " | 10 | 30 | 12.0 ± 0.0 | 9.5 ± 1.3 | 90 |
| JP-4 (HVP) | 100 | 5 | 12.8 ± 0.8 | 10.5 ± 0.5 | 106 |
| " | 100 | 10 | 16.0 ± 1.0 | 14.5 ± 0.5 | 182 |
| " | 100 | 20 | 22.0 ± 1.0 | 19.8 ± 1.0 | 343 |
| " | 100 | 30 | 25.3 ± 1.5 | 22.0 ± 0.0 | 438 |
| JP-4 (HVP) | 250 | 5 | 17.3 ± 0.6 | 17.5 ± 0.5 | 238 |
| " | 250 | 10 | 21.0 ± 1.0 | 21.7 ± 1.5 | 357 |
| " | 250 | 20 | 29.3 ± 0.6 | 28.3 ± 0.6 | 653 |
| " | 250 | 30 | 33.0 ± 1.0 | 33.7 ± 2.1 | 873 |
| JP-4 (HVP) | 500 | 5 | 20.7 ± 3.8 | 20.0 ± 3.6 | 325 |
| " | 500 | 10 | 28.2 ± 3.3 | 25.7 ± 4.5 | 568 |
| " | 500 | 20 | 38.7 ± 1.2 | 30.7 ± 2.3 | 931 |
| " | 500 | 30 | 40.0 ± 1.7 | 33.0 ± 0.0 | 1037 |

## TABLE 10 (continued)

| Fuel | Fuel flow rate ($\mu\ell$/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-5 | 10 | 5 | 4.6 ± 2.3 | 4.8 ± 2.5 | 17 |
| " | 10 | 10 | 6.7 ± 3.1 | 7.7 ± 4.0 | 40 |
| " | 10 | 20 | 11.1 ± 1.2 | 12.1 ± 2.4 | 106 |
| " | 10 | 30 | 14.5 ± 1.5 | 15.7 ± 2.0 | 178 |
| JP-5 | 100 | 5 | 19.7 ± 1.5 | 6.5 ± 1.3 | 100 |
| " | 100 | 10 | 32.0 ± 0.0 | 9.4 ± 0.7 | 235 |
| " | 100 | 20 | 32.0 ± 0.0 | 15.3 ± 0.8 | 385 |
| " | 100 | 30 | 32.0 ± 0.0 | 17.5 ± 0.5 | 440 |
| JP-8 | 10 | 5 | 5.7 ± 0.6 | 5.7 ± 0.6 | 26 |
| " | 10 | 10 | 8.8 ± 0.8 | 8.8 ± 0.8 | 61 |
| " | 10 | 20 | 12.3 ± 0.8 | 12.2 ± 0.6 | 118 |
| " | 10 | 30 | 15.2 ± 0.7 | 15.4 ± 0.5 | 183 |
| JP-8 | 100 | 5 | 14.2 ± 0.8 | 9.7 ± 1.5 | 108 |
| " | 100 | 10 | 24.5 ± 0.5 | 18.0 ± 3.6 | 346 |
| " | 100 | 20 | 34.3 ± 1.2 | 20.0 ± 1.3 | 539 |
| " | 100 | 30 | 36.0 ± 0.0 | 24.0 ± 0.9 | 679 |
| JP-8 | 250 | 5 | 31.2 ± 4.4 | 13.3 ± 3.5 | 326 |
| " | 250 | 10 | 35.7 ± 1.2 | 17.7 ± 1.5 | 495 |
| " | 250 | 20 | 36.2 ± 0.8 | 22.0 ± 3.6 | 625 |
| " | 250 | 30 | 36.5 ± 0.5 | 25.3 ± 0.6 | 726 |

TABLE 11. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 23°C (73°F). AIR FLOW RATE 6.1 m/sec. ANGLE OF INCLINATION 10 DEGREES

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (LVP) | 10 | 5 | 5.0 ± 0.6 | 5.2 ± 0.8 | 20 |
| " | 10 | 10 | 7.4 ± 0.2 | 7.6 ± 0.2 | 44 |
| " | 10 | 20 | 8.6 ± 0.5 | 9.3 ± 0.2 | 63 |
| " | 10 | 30 | 9.7 ± 0.3 | 10.3 ± 0.3 | 78 |
| JP-4 (LVP) | 100 | 5 | 12.7 ± 1.1 | 13.1 ± 0.9 | 130 |
| " | 100 | 10 | 18.2 ± 0.9 | 18.2 ± 0.5 | 261 |
| " | 100 | 20 | 23.8 ± 1.1 | 23.0 ± 1.0 | 430 |
| " | 100 | 30 | 27.1 ± 1.4 | 26.5 ± 0.9 | 563 |
| JP-4 (LVP) | 250 | 5 | 20.0 ± 4.0 | 19.0 ± 3.5 | 299 |
| " | 250 | 10 | 27.1 ± 2.4 | 24.7 ± 2.3 | 526 |
| " | 250 | 20 | 36.1 ± 1.8 | 32.3 ± 2.1 | 916 |
| " | 250 | 30 | 38.1 ± 0.5 | 35.0 ± 1.0 | 1047 |
| JP-4 (LVP) | 500 | 5 | 26.2 ± 1.7 | 23.3 ± 2.3 | 481 |
| " | 500 | 10 | 35.9 ± 0.1 | 29.7 ± 0.6 | 837 |
| " | 500 | 20 | 38.5 ± 0.8 | 34.7 ± 1.5 | 1049 |
| " | 500 | 30 | 40.8 ± 1.0 | 36.0 ± 1.0 | 1154 |
| JP-4 (HVP) | 10 | 5 | 5.4 ± 0.5 | 5.3 ± 0.8 | 22 |
| " | 10 | 10 | 7.1 ± 0.6 | 7.7 ± 0.6 | 43 |
| " | 10 | 20 | 8.5 ± 0.5 | 9.8 ± 0.3 | 66 |
| " | 10 | 30 | 9.4 ± 0.8 | 10.8 ± 0.3 | 80 |
| JP-4 (HVP) | 100 | 5 | 12.3 ± 1.8 | 12.8 ± 1.1 | 124 |
| " | 100 | 10 | 16.3 ± 1.5 | 17.0 ± 1.0 | 218 |
| " | 100 | 20 | 22.0 ± 2.7 | 23.7 ± 1.2 | 409 |
| " | 100 | 30 | 26.2 ± 1.8 | 28.0 ± 2.7 | 576 |
| JP-4 (HVP) | 250 | 5 | 17.3 ± 1.2 | 17.6 ± 0.5 | 239 |
| " | 250 | 10 | 23.7 ± 0.6 | 23.0 ± 1.0 | 428 |
| " | 250 | 20 | 31.0 ± 1.0 | 31.3 ± 1.2 | 763 |
| " | 250 | 30 | 38.0 ± 1.0 | 35.0 ± 1.7 | 1045 |
| JP-4 (HVP) | 500 | 5 | 25.5 ± 4.8 | 21.7 ± 1.5 | 434 |
| " | 500 | 10 | 35.0 ± 0.0 | 29.0 ± 1.7 | 797 |
| " | 500 | 20 | 37.8 ± 0.3 | 33.3 ± 2.1 | 988 |
| " | 500 | 30 | 39.7 ± 0.6 | 37.7 ± 0.6 | 1174 |

TABLE 11 (continued)

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-5 | 10 | 5 | 7.5 ± 0.5 | 5.7 ± 0.6 | 33 |
| " | 10 | 10 | 10.0 ± 1.3 | 8.5 ± 1.3 | 67 |
| " | 10 | 20 | 15.4 ± 1.4 | 11.5 ± 0.5 | 139 |
| " | 10 | 30 | 19.1 ± 0.9 | 14.7 ± 0.6 | 220 |
| JP-5 | 100 | 5 | 23.0 ± 1.0 | 5.3 ± 0.6 | 96 |
| " | 100 | 10 | 32.0 ± 0.0 | 8.9 ± 0.8 | 223 |
| " | 100 | 20 | 32.0 ± 0.0 | 13.8 ± 1.0 | 348 |
| " | 100 | 30 | 32.0 ± 0.0 | 16.0 ± 1.0 | 402 |
| JP-8 | 10 | 5 | 6.5 ± 0.9 | 6.5 ± 0.9 | 33 |
| " | 10 | 10 | 10.3 ± 0.3 | 9.3 ± 0.6 | 76 |
| " | 10 | 20 | 14.2 ± 0.8 | 13.3 ± 0.6 | 148 |
| " | 10 | 30 | 17.4 ± 0.8 | 16.8 ± 0.3 | 230 |
| JP-8 | 100 | 5 | 19.5 ± 1.5 | 10.7 ± 2.9 | 163 |
| " | 100 | 10 | 32.3 ± 1.2 | 15.7 ± 1.5 | 398 |
| " | 100 | 20 | 34.2 ± 0.3 | 18.8 ± 0.3 | 505 |
| " | 100 | 30 | 34.8 ± 1.0 | 23.3 ± 0.6 | 638 |

TABLE 12. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 23°C (73°F). QUIESCENT ATMOSPHERE. ANGLE OF INCLINATION 0 DEGREE

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (HVP) | 5 | 5 | 4.4 ± 0.5 | 4.4 ± 0.5 | 15 |
| " | 5 | 10 | 5.2 ± 0.3 | 5.4 ± 0.3 | 22 |
| " | 5 | 20 | 7.0 ± 0.0 | 7.5 ± 0.0 | 41 |
| " | 5 | 30 | 8.1 ± 0.4 | 8.8 ± 0.6 | 56 |
| JP-4 (HVP) | 10 | 5 | 7.2 ± 0.2 | 7.2 ± 0.2 | 41 |
| " | 10 | 10 | 8.3 ± 0.3 | 8.2 ± 0.3 | 54 |
| " | 10 | 20 | 10.4 ± 0.2 | 10.6 ± 0.4 | 86 |
| " | 10 | 30 | 11.7 ± 0.3 | 11.9 ± 0.2 | 109 |
| JP-4 (HVP) | 25 | 5 | 9.0 ± 0.0 | 9.0 ± 0.0 | 64 |
| " | 25 | 10 | 11.1 ± 0.2 | 11.2 ± 0.2 | 98 |
| " | 25 | 20 | 14.2 ± 0.3 | 14.2 ± 0.3 | 158 |
| " | 25 | 30 | 15.0 ± 1.0 | 16.2 ± 0.3 | 191 |
| JP-4 (HVP) | 50 | 5 | 10.8 ± 0.3 | 11.0 ± 0.0 | 94 |
| " | 50 | 10 | 14.0 ± 0.0 | 15.0 ± 0.0 | 165 |
| " | 50 | 20 | 16.7 ± 1.2 | 18.3 ± 0.6 | 240 |
| " | 50 | 30 | 18.5 ± 1.8 | 22.0 ± 1.0 | 320 |
| JP-4 (HVP) | 500 | 5 | 23.8 ± 0.3 | 24.5 ± 0.9 | 459 |
| " | 500 | 10 | 30.0 ± 1.0 | 31.3 ± 1.2 | 738 |
| " | 500 | 20 | 36.7 ± 0.6 | 40.3 ± 1.5 | 1162 |
| " | 500 | 30 | 42.7 ± 0.6 | 42.3 ± 1.2 | 1419 |
| JP-4 (HVP) | 1000 | 5 | 23.7 ± 0.8 | 24.3 ± 0.6 | 452 |
| " | 1000 | 10 | 29.3 ± 1.3 | 30.7 ± 0.3 | 707 |
| " | 1000 | 20 | 36.3 ± 2.1 | 39.0 ± 1.0 | 1113 |
| " | 1000 | 30 | 41.0 ± 1.7 | 44.0 ± 1.7 | 1417 |
| JP-5 | 10 | 5 | 6.0 ± 0.1 | 6.0 ± 0.1 | 30 |
| " | 10 | 10 | 9.0 ± 0.3 | 9.0 ± 0.3 | 63 |
| " | 10 | 20 | 12.8 ± 0.4 | 12.9 ± 0.6 | 129 |
| " | 10 | 30 | 15.4 ± 0.2 | 15.4 ± 0.2 | 185 |
| JP-5 | 25 | 5 | 6.1 ± 0.5 | 6.0 ± 0.7 | 29 |
| " | 25 | 10 | 8.9 ± 0.5 | 12.1 ± 3.4 | 85 |
| " | 25 | 20 | 13.6 ± 0.2 | 22.7 ± 1.2 | 242 |
| " | 25 | 30 | 16.8 ± 0.8 | 26.2 ± 1.3 | 359 |

(continued)

TABLE 12 (continued)

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-5 | 50 | 5 | 6.2 ± 0.4 | 12.7 ± 1.2 | 62 |
| " | 50 | 10 | 9.1 ± 0.5 | 20.2 ± 4.1 | 144 |
| " | 50 | 20 | 13.9 ± 1.8 | 27.2 ± 0.8 | 297 |
| " | 50 | 30 | 16.2 ± 0.3 | 28.7 ± 1.5 | 366 |
| JP-8 | 5 | 5 | 3.8 ± 1.4 | 3.0 ± 1.4 | 12 |
| " | 5 | 10 | 6.6 ± 1.5 | 6.7 ± 1.5 | 34 |
| " | 5 | 20 | 10.1 ± 0.8 | 8.1 ± 1.2 | 65 |
| " | 5 | 30 | 12.2 ± 0.7 | 12.3 ± 0.6 | 118 |
| JP-8 | 10 | 5 | 7.5 ± 0.5 | 7.5 ± 0.5 | 44 |
| " | 10 | 10 | 10.0 ± 0.0 | 10.0 ± 0.0 | 79 |
| " | 10 | 20 | 13.7 ± 0.6 | 14.0 ± 0.0 | 150 |
| " | 10 | 30 | 16.5 ± 0.5 | 17.0 ± 0.0 | 220 |
| JP-8 | 25 | 5 | 8.3 ± 0.6 | 8.3 ± 0.6 | 54 |
| " | 25 | 10 | 12.2 ± 0.4 | 12.2 ± 0.4 | 117 |
| " | 25 | 20 | 16.5 ± 0.0 | 16.5 ± 0.0 | 214 |
| " | 25 | 30 | 19.9 ± 0.8 | 20.1 ± 0.5 | 314 |
| JP-8 | 50 | 5 | 8.2 ± 1.3 | 9.2 ± 1.9 | 59 |
| " | 50 | 10 | 12.2 ± 1.1 | 13.3 ± 1.6 | 128 |
| " | 50 | 20 | 18.2 ± 1.4 | 20.4 ± 1.6 | 292 |
| " | 50 | 30 | 22.5 ± 1.3 | 24.5 ± 1.3 | 433 |
| JP-8 | 100 | 5 | 8.2 ± 0.3 | 21.3 ± 5.7 | 137 |
| " | 100 | 10 | 10.3 ± 2.4 | 26.8 ± 1.6 | 218 |
| " | 100 | 20 | 18.8 ± 0.8 | 30.3 ± 1.2 | 449 |
| " | 100 | 30 | 23.7 ± 0.6 | 32.0 ± 0.0 | 595 |
| JP-8 | 250 | 5 | 6.3 ± 0.6 | 6.8 ± 0.8 | 34 |
| " | 250 | 10 | 8.7 ± 0.6 | 9.0 ± 1.0 | 61 |
| " | 250 | 20 | 12.2 ± 1.2 | 12.7 ± 1.2 | 121 |
| " | 250 | 30 | 13.5 ± 0.9 | 12.7 ± 1.2 | 135 |
| JP-4 (HVP)/ JP-8 (10/90) | 50 | 5 | 7.6 ± 3.1 | 7.7 ± 3.3 | 46 |
| " | 50 | 10 | 16.5 ± 4.5 | 13.7 ± 2.9 | 177 |
| " | 50 | 20 | 19.5 ± 3.5 | 19.2 ± 2.6 | 294 |
| " | 50 | 30 | 22.7 ± 5.4 | 22.7 ± 4.5 | 404 |

(continued)

TABLE 12 (continued)

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (HVP)/ JP-8 (10/90) | 100 | 5 | 9.3 ± 1.2 | 10.3 ± 0.3 | 76 |
| " | 100 | 10 | 18.5 ± 1.4 | 12.3 ± 2.5 | 179 |
| " | 100 | 20 | 27.7 ± 0.6 | 20.3 ± 1.0 | 442 |
| " | 100 | 30 | 31.0 ± 0.0 | 23.3 ± 0.6 | 568 |
| AvGas[a] | 100 | 5 | 5.2 | 5.5 | 22 |
| " | 100 | 10 | 5.6 | 6.5 | 29 |
| " | 100 | 20 | 5.6 | 6.6 | 29 |
| " | 100 | 30 | 6.0 | 6.8 | 32 |
| AvGas | 250 | 5 | 9.0 | 9.4 | 66 |
| " | 250 | 10 | 9.0 | 10.0 | 71 |
| " | 250 | 20 | 9.5 | 10.5 | 78 |
| " | 250 | 30 | 9.8 | 10.5 | 81 |
| AvGas | 500 | 5 | 13.0 | 15.0 | 153 |
| " | 500 | 10 | 14.0 | 15.0 | 165 |
| " | 500 | 20 | 14.5 | 16.0 | 182 |
| " | 500 | 30 | 14.5 | 17.0 | 194 |
| AvGas | 1000 | 5 | 17.5 | 19.0 | 261 |
| " | 1000 | 10 | 18.0 | 19.0 | 269 |
| " | 1000 | 20 | 19.0 | 20.5 | 306 |
| " | 1000 | 30 | 20.0 | 22.0 | 346 |
| AvGas | 1400 | 5 | 21.5 | 22.0 | 371 |
| " | 1400 | 10 | 23.0 | 24.0 | 433 |
| " | 1400 | 20 | 23.5 | 26.0 | 480 |
| " | 1400 | 30 | 24.0 | 26.5 | 499 |

[a] Surface-dispersion data for AvGas are based upon a single experiment under each test condition.

TABLE 13. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 23°C (73°F). QUIESCENT ATMOSPHERE. ANGLE OF INCLINATION 90 DEGREES

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) | | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| | | | Average length | Average width | |
| JP-4 (HVP) | 10 | 5 | 7.1 ± 0.2 | 6.3 ± 0.6 | 36 |
| " | 10 | 10 | 8.8 ± 0.3 | 8.3 ± 0.3 | 57 |
| " | 10 | 20 | 11.3 ± 0.5 | 10.2 ± 0.3 | 90 |
| " | 10 | 30 | 13.0 ± 0.5 | 11.0 ± 0.5 | 112 |
| JP-4 (HVP) | 50 | 5 | 12.3 ± 0.6 | 10.7 ± 0.8 | 103 |
| " | 50 | 10 | 16.7 ± 0.8 | 13.9 ± 0.8 | 182 |
| " | 50 | 20 | 22.9 ± 1.8 | 15.7 ± 1.8 | 283 |
| " | 50 | 30 | 26.4 ± 0.7 | 18.2 ± 1.6 | 378 |
| JP-8 | 5 | 5 | 7.7 ± 0.6 | 4.6 ± 0.4 | 28 |
| " | 5 | 10 | 10.9 ± 1.2 | 6.1 ± 0.6 | 53 |
| " | 5 | 10 | 17.0 ± 0.6 | 8.1 ± 0.5 | 108 |
| " | 5 | 30 | 18.6 ± 1.2 | 9.5 ± 0.1 | 139 |
| JP-8 | 10 | 5 | 9.6 ± 1.7 | 4.7 ± 0.4 | 35 |
| " | 10 | 10 | 15.6 ± 1.2 | 6.6 ± 0.4 | 81 |
| " | 10 | 20 | 24.2 ± 0.5 | 8.7 ± 0.6 | 166 |

TABLE 14. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 32°C (90°F). QUIESCENT ATMOSPHERE. ANGLE OF INCLINATION 0 DEGREE

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (HVP) | 50 | 5 | 7.4 ± 1.0 | 10.5 ± 1.3 | 61 |
| " | 50 | 10 | 9.7 ± 0.3 | 14.8 ± 1.1 | 112 |
| " | 50 | 20 | 11.6 ± 0.4 | 19.1 ± 0.8 | 174 |
| " | 50 | 30 | 13.3 ± 1.5 | 21.8 ± 1.9 | 227 |
| JP-4 (HVP) | 100 | 5 | 9.8 ± 0.9 | 14.3 ± 2.5 | 111 |
| " | 100 | 10 | 12.0 ± 1.8 | 19.4 ± 1.4 | 183 |
| " | 100 | 20 | 17.5 ± 1.3 | 25.4 ± 1.0 | 349 |
| " | 100 | 30 | 19.7 ± 0.8 | 30.0 ± 0.5 | 464 |
| JP-5 | 10 | 5 | 5.3 ± 0.3 | 5.7 ± 0.6 | 24 |
| " | 10 | 10 | 8.2 ± 0.3 | 9.0 ± 1.0 | 58 |
| " | 10 | 20 | 11.8 ± 0.5 | 11.8 ± 1.6 | 105 |
| " | 10 | 30 | 14.0 ± 0.5 | 17.2 ± 1.0 | 189 |
| JP-5 | 25 | 5 | 6.7 ± 0.8 | 7.2 ± 0.9 | 38 |
| " | 25 | 10 | 9.8 ± 1.3 | 11.1 ± 1.0 | 86 |
| " | 25 | 20 | 14.2 ± 1.8 | 16.2 ± 1.1 | 180 |
| " | 25 | 30 | 17.5 ± 0.9 | 19.1 ± 0.5 | 262 |
| JP-5 | 50 | 5 | 4.3 ± 0.6 | 8.7 ± 0.6 | 30 |
| " | 50 | 10 | 9.3 ± 1.0 | 22.8 ± 1.4 | 167 |
| " | 50 | 20 | 15.5 ± 1.8 | 25.0 ± 1.5 | 304 |
| " | 50 | 30 | 18.3 ± 0.6 | 28.5 ± 0.5 | 413 |
| JP-8 | 50 | 5 | 7.6 ± 2.3 | 8.5 ± 2.3 | 51 |
| " | 50 | 10 | 14.1 ± 1.6 | 15.0 ± 1.7 | 167 |
| " | 50 | 20 | 20.4 ± 0.8 | 22.0 ± 1.1 | 353 |
| " | 50 | 30 | 24.2 ± 0.3 | 26.3 ± 1.0 | 500 |
| JP-8 | 100 | 5 | 8.8 ± 0.8 | 18.5 ± 3.0 | 128 |
| " | 100 | 10 | 15.7 ± 1.0 | 23.7 ± 2.5 | 292 |
| " | 100 | 20 | 22.5 ± 1.5 | 28.8 ± 0.6 | 509 |
| " | 100 | 30 | 26.3 ± 1.8 | 31.0 ± 0.0 | 641 |

TABLE 15. DISPERSION OF LEAKING JET FUELS ON ALCLAD SURFACE AT 23°C (73°F). EXTENDED MEASUREMENT TIME AND LONGER FLOW DISTANCE EXPERIMENTS. AIR FLOW RATE 6.1 m/sec. ANGLE OF INCLINATION 10 DEGREES

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (HVP) | 500 | 5 | 23.0 ± 2.0 | 22.8 ± 2.3 | 412 |
| " | 500 | 10 | 30.5 ± 2.2 | 27.7 ± 1.3 | 663 |
| " | 500 | 20 | 40.7 ± 1.5 | 33.0 ± 1.0 | 1054 |
| " | 500 | 30 | 48.3 ± 1.5 | 36.3 ± 1.5 | 1379 |
| JP-5 | 10 | 5 | 4.5 ± 0.4 | 4.5 ± 0.4 | 16 |
| " | 10 | 10 | 7.7 ± 0.4 | 7.7 ± 0.4 | 47 |
| " | 10 | 20 | 11.3 ± 0.4 | 11.3 ± 0.2 | 100 |
| " | 10 | 30 | 14.3 ± 0.4 | 14.5 ± 0.0 | 162 |
| " | 10 | 60 | 20.8 ± 0.4 | 20.5 ± 0.0 | 326 |
| " | 10 | 120 | 31.8 ± 0.4 | 25.8 ± 2.5 | 502 |
| " | 10 | 180 | 31.8 ± 0.4 | 28.3 ± 3.2 | 705 |
| JP-8 | 100 | 5 | 17.7 ± 3.5 | 10.0 ± 3.0 | 139 |
| " | 100 | 10 | 29.3 ± 2.1 | 16.8 ± 3.9 | 388 |
| " | 100 | 20 | 39.7 ± 5.9 | 19.7 ± 2.3 | 613 |
| " | 100 | 30 | 50.7 ± 0.6 | 22.3 ± 1.2 | 889 |

TABLE 16. DISPERSION OF LEAKING JET FUELS ON PAINTED ALCLAD SURFACE AT 23°C (73°F). AIR FLOW RATE 6.1 m/sec. ANGLE OF INCLINATION 0 DEGREE

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (LVP) | 100 | 5 | 15.0 ± 0.0 | 15.0 ± 0.0 | 177 |
| " | 100 | 10 | 19.0 ± 0.0 | 19.0 ± 0.0 | 284 |
| " | 100 | 20 | 23.3 ± 0.6 | 21.7 ± 0.6 | 397 |
| " | 100 | 30 | 25.7 ± 1.5 | 22.3 ± 0.6 | 450 |
| JP-4 (LVP) | 250 | 5 | 18.7 ± 2.3 | 18.7 ± 2.3 | 274 |
| " | 250 | 10 | 25.0 ± 1.0 | 25.0 ± 1.0 | 491 |
| " | 250 | 20 | 32.0 ± 0.0 | 31.7 ± 0.6 | 796 |
| " | 250 | 30 | 36.0 ± 1.0 | 34.0 ± 1.0 | 961 |
| JP-4 (LVP) | 500 | 5 | 23.3 ± 1.2 | 23.3 ± 1.2 | 428 |
| " | 500 | 10 | 29.5 ± 0.9 | 29.8 ± 0.8 | 691 |
| " | 500 | 20 | 38.7 ± 1.2 | 32.0 ± 1.7 | 972 |
| " | 500 | 30 | 42.3 ± 0.6 | 33.7 ± 1.2 | 1119 |
| JP-4 (HVP) | 100 | 5 | 14.0 ± 1.0 | 14.0 ± 1.0 | 154 |
| " | 100 | 10 | 18.6 ± 0.6 | 18.8 ± 1.0 | 275 |
| " | 100 | 20 | 23.3 ± 0.5 | 23.2 ± 0.4 | 425 |
| " | 100 | 30 | 26.3 ± 0.6 | 26.3 ± 0.6 | 545 |
| JP-4 (HVP) | 250 | 5 | 17.4 ± 1.5 | 17.4 ± 1.5 | 240 |
| " | 250 | 10 | 24.0 ± 1.7 | 24.0 ± 1.7 | 452 |
| " | 250 | 20 | 30.7 ± 1.3 | 30.7 ± 1.3 | 739 |
| " | 250 | 30 | 33.7 ± 0.6 | 33.7 ± 0.6 | 890 |
| JP-4 (HVP) | 500 | 5 | 23.8 ± 1.8 | 23.7 ± 1.6 | 444 |
| " | 500 | 10 | 30.5 ± 1.5 | 30.2 ± 1.0 | 723 |
| " | 500 | 20 | 38.3 ± 2.5 | 35.0 ± 3.5 | 1054 |
| " | 500 | 30 | 43.7 ± 1.5 | 37.7 ± 3.8 | 1292 |
| JP-5 | 10 | 5 | 6.0 ± 0.0 | 6.0 ± 0.0 | 28 |
| " | 10 | 10 | 9.3 ± 0.9 | 9.4 ± 0.8 | 68 |
| " | 10 | 20 | 13.6 ± 1.4 | 13.7 ± 1.4 | 146 |
| " | 10 | 30 | 16.4 ± 0.5 | 16.5 ± 0.5 | 212 |
| JP-5 | 25 | 5 | 6.0 ± 0.0 | 6.0 ± 0.0 | 28 |
| " | 25 | 10 | 8.5 ± 0.9 | 8.5 ± 0.9 | 57 |
| " | 25 | 20 | 9.9 ± 1.0 | 9.9 ± 1.0 | 77 |
| " | 25 | 30 | 11.0 ± 0.9 | 11.1 ± 0.8 | 96 |

TABLE 16 (continued)

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-5 | 50 | 5 | 5.0 ± 0.4 | 5.0 ± 0.4 | 19 |
| " | 50 | 10 | 6.0 ± 0.0 | 5.8 ± 0.1 | 27 |
| " | 50 | 20 | 8.5 ± 0.5 | 8.5 ± 0.5 | 57 |
| " | 50 | 30 | 9.9 ± 0.3 | 9.9 ± 0.3 | 77 |
| JP-5 | 100 | 5 | 4.2 ± 0.3 | 4.2 ± 0.3 | 14 |
| " | 100 | 10 | 6.0 ± 0.0 | 6.0 ± 0.0 | 28 |
| " | 100 | 20 | 8.1 ± 0.2 | 8.1 ± 0.2 | 52 |
| " | 100 | 30 | 9.0 ± 0.1 | 9.2 ± 0.4 | 65 |
| JP-8 | 25 | 5 | 9.5 ± 0.5 | 9.5 ± 0.5 | 71 |
| " | 25 | 10 | 12.8 ± 0.8 | 12.8 ± 0.8 | 129 |
| " | 25 | 20 | 17.7 ± 0.8 | 17.7 ± 0.8 | 246 |
| " | 25 | 30 | 21.0 ± 0.9 | 21.0 ± 0.9 | 346 |
| JP-8 | 50 | 5 | 8.2 ± 0.8 | 8.2 ± 0.8 | 52 |
| " | 50 | 10 | 12.1 ± 1.4 | 13.1 ± 3.0 | 124 |
| " | 50 | 20 | 16.2 ± 2.0 | 19.2 ± 4.2 | 245 |
| " | 50 | 30 | 19.0 ± 2.0 | 26.9 ± 2.0 | 401 |
| JP-8 | 100 | 5 | 6.5 ± 0.5 | 6.6 ± 0.4 | 34 |
| " | 100 | 10 | 8.8 ± 0.3 | 8.8 ± 0.3 | 61 |
| " | 100 | 20 | 11.7 ± 0.3 | 11.7 ± 0.3 | 107 |
| " | 100 | 30 | 13.8 ± 0.3 | 13.8 ± 0.3 | 150 |

TABLE 17. DISPERSION OF LEAKING JET FUELS ON UNCLAD ALUMINUM ALLOY SURFACE AT 23°C (73°F). AIR FLOW RATE 6.1 m/sec. ANGLE OF INCLINATION 0 DEGREE

| Fuel | Fuel flow rate (μℓ/min) | Time (min) | Spot dimensions (cm) Average length | Spot dimensions (cm) Average width | Average spot area ($cm^2$) |
|---|---|---|---|---|---|
| JP-4 (LVP) | 100 | 5 | 14.8 ± 0.6 | 15.2 ± 0.6 | 177 |
| " | 100 | 10 | 18.7 ± 0.6 | 19.0 ± 0.9 | 279 |
| " | 100 | 20 | 22.7 ± 0.6 | 23.7 ± 0.6 | 421 |
| " | 100 | 30 | 24.8 ± 0.5 | 26.5 ± 0.5 | 516 |
| JP-4 (HVP) | 100 | 5 | 13.8 ± 0.8 | 14.1 ± 0.6 | 153 |
| " | 100 | 10 | 17.7 ± 0.3 | 18.7 ± 0.6 | 259 |
| " | 100 | 20 | 22.6 ± 0.5 | 23.2 ± 0.3 | 411 |
| " | 100 | 30 | 25.8 ± 0.3 | 26.3 ± 0.3 | 534 |
| JP-5 | 100 | 5 | 4.8 ± 0.3 | 5.0 ± 0.5 | 19 |
| " | 100 | 10 | 6.0 ± 0.5 | 6.5 ± 0.5 | 31 |
| " | 100 | 20 | 7.5 ± 0.5 | 7.9 ± 0.7 | 47 |
| " | 100 | 30 | 8.7 ± 0.6 | 8.8 ± 0.7 | 60 |
| JP-8 | 100 | 5 | 10.2 ± 0.4 | 14.7 ± 0.6 | 117 |
| " | 100 | 10 | 15.5 ± 2.2 | 20.3 ± 1.2 | 247 |
| " | 100 | 20 | 20.2 ± 0.3 | 23.2 ± 2.8 | 367 |
| " | 100 | 30 | 23.7 ± 0.6 | 27.5 ± 2.3 | 511 |

C. Leakage Conditions That Caused Dripping of Fuels

TABLE 18. LEAKAGE CONDITIONS THAT CAUSED DRIPPING OF FUELS[a,b]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (μℓ/min.) \ Fluid | 3.3°C (38°F) None | | | 23°C (73°F) 6.1 m/sec (20 ft/sec) | | | | 23°C (73°F) None | | | | | 32°C (90°F) None | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4[c] (HVP) | JP-5 | JP-8 | JP-4[d] (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[e] | AvGas[f] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | ● | ● | ● | ● | | ● | | | | | |
| 0 | 10 | | ● | | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 25 | | ◉ | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 50 | ● | ◉ | ◉ | ● | ● | ◉ | ● | ● | ◉ | ● | ● | | ● | ● | ● |
| 0 | 100 | ● | | ◉ | ● | ● | ◉ | ● | | | ◉ | ◉ | ● | ● | | ● |
| 0 | 250 | | | ◉ | ● | ● | ◉ | ◉ | | | ◉ | | ● | | | |
| 0 | 500 | | | | ● | ● | | ◉ | ● | | | | ● | | | |
| 0 | 1000 | | | | ◉ | ◉ | | | ◉ | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| 5 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | ● | ● | ◉ | ◉ | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ◉ | | | | | | | | |
| 5 | 500 | | | | ◉ | ◉ | | | | | | | | | | |
| 10 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | ● | ● | ◉ | ◉ | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ◉ | ◉ | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ◉ | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Experiments during which drippino of the fluids occurred are encircled

[b] Measurement time was 30 minı ıes for all experiments shown in this table

[c] High vapor pressure sample

[d] Low vapor pressure sample

[e] JP-4/JP-8 in 10/90 volume ratio

[f] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

TABLE 18 (continued)[a,b]

| Angle (deg) | Panel / Fuel flow rate (μℓ/min.) / Fluid | Alclad | | | | Unclad aluminum alloy | | | | Polyurethane latex-coated surface | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4 (LVP)[c] | JP-4 (HVP)[d] | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | ● | | | | | | | | | |
| 0 | 5 | ● | ● | ● | ● | | | | | | | | |
| 0 | 10 | ● | ● | ● | ● | | | | | | | ● | |
| 0 | 25 | ● | ● | ● | ● | | | | | | | ◉ | ● |
| 0 | 50 | ● | ● | ◉ | ● | | | | | | | ◉ | ◉ |
| 0 | 100 | ● | ● | ◉ | ● | ● | ● | ◉ | ● | ● | ● | ◉ | ◉ |
| 0 | 250 | ● | ● | ◉ | ◉ | | | | | ● | ● | | |
| 0 | 500 | ● | ● | | ◉ | | | | | ◉ | ● | | |
| 0 | 1000 | ◉ | ◉ | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ◉ | ◉ | | | | | | | | |
| 5 | 250 | ● | ● | | ◉ | | | | | | | | |
| 5 | 500 | ◉ | ◉ | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ◉ | ◉ | | | | | | | | |
| 5 | 250 | ● | ● | | | | | | | | | | |
| 5 | 500 | ◉ | ◉ | | | | | | | | | | |

[a] Experiments during which dripping of the fluids occurred are encircled.
[b] Measurement time was 30 minutes for all experiments shown in this table.
[c] Low vapor pressure sample
[d] High vapor pressure sample

## D. Sustained Burning of Leaking Fuels

TABLE 19. RESULTS OF TESTS FOR SUSTAINED BURNING AT TEMPERATURES FROM 3.3°C TO 98°C (38°F TO 208°F). QUIESCENT ATMOSPHERE. ANGLE OF INCLINATION 0 DEGREE

| Temperature (°C) | Temperature (°F) | Fuel flow rate (μℓ/min) | Fuel burning characteristics: JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP)/ JP-8 (10/90) | JP-4 (HVP)/ JP-8 (50/50) | AvGas |
|---|---|---|---|---|---|---|---|---|---|
| 3.3 | 38 | 500 | E[a] | E | E | E | | | |
| | | 600 | | E | | | | | |
| | | 700 | | SB[b] | | | | | |
| | | 800 | | SB | | | | | |
| | | 900 | | SB | | | | | |
| | | 1000 | E | SB | E | E | | | |
| | | 1500 | E | | E | E | | | |
| | | 2000 | E | | E | E | | | |
| | | 2500 | E | | E | E | | | |
| | | 3000 | SB | | E | E | | | |
| | | 3500 | SB | | E | E | | | |
| | | 4000 | SB | | E | E | | | |
| | | 4500 | SB | | E | E | | | |
| | | 5000 | SB | | E | E | | | |
| | | 5500 | | E | E | | | E | |
| | | 6000 | | | E | E | | SB | |
| | | 6500 | | | E | E | | | |
| | | 7000 | | | E | E | | | |
| | | 7500 | | | E | E | | | |
| | | 8000 | | | E | E | | | |
| 10 | 50 | 4500 | | | | | | E | |
| | | 5000 | | | | | | SB | |
| 24 | 75 | 100 | | E | | | | | |
| | | 200 | | E | | | | | |
| | | 300 | | E | | | | | |
| | | 400 | | SB | | | | | |
| | | 500 | E | SB | E | E | | | |
| | | 600 | SB | SB | | | | | |
| | | 700 | | SB | | | | | |
| | | 1000 | SB | | E | E | | | |
| | | 1500 | | | E | E | | | |
| | | 2000 | SB | | E | E | | E | |
| | | 2500 | SB | | E | E | | SB | |
| | | 3000 | | | E | E | | SB | |
| | | 3500 | SB | | E | E | | | |
| | | 4000 | | | E | E | | | |
| | | 4500 | | | E | E | | | |
| | | 5000 | SB | | E | E | | | |
| | | 5500 | | | E | E | | | |
| | | 6000 | | | E | E | | | |
| | | 6500 | | | E | E | | | |
| | | 7000 | | | E | E | | | |
| | | 7500 | | | E | E | | | |
| | | 8000 | | | E | E | | | |

(continued)

[a]Extinguished upon removal of the ignition source.

[b]Sustained burning.

TABLE 19 (continued)

| Temperature (°C) | Temperature (°F) | Fuel flow rate (μℓ/min) | Fuel burning characteristics: JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP)/ JP-8 (10/90) | JP-4 (HVP)/ JP-8 (50/50) | Avgas |
|---|---|---|---|---|---|---|---|---|---|
| 28 | 82 | 200 | | | | | | | E |
| | | 300 | | | | | | | SB |
| | | 400 | | | | | | | SB |
| 38 | 100 | 300 | E | E | | | | | |
| | | 400 | SB | SB | | | | | |
| | | 500 | SB | | | | | | |
| | | 600 | SB | | | | | | |
| | | 1000 | | | | | | E | |
| | | 1250 | | | | | | SB | |
| | | 1500 | | | | | | SB | |
| | | 1750 | | | | | | SB | |
| | | 2000 | | | | | | SB | |
| | | 2500 | | | | | | SB | |
| | | 3000 | | | | | | SB | |
| | | 8000 | | | E | E | | | |
| 49 | 120 | 9000 | | | | E | | | |
| 52 | 125 | 1000 | | | | | | E | |
| | | 1250 | | | | | | SB | |
| | | 1500 | | | | | | SB | |
| | | 1750 | | | | | | SB | |
| | | 2000 | | | | | | SB | |
| | | 2500 | | | | | | SB | |
| | | 3000 | | | | | | SB | |
| 60 | 140 | 2000 | | | | | E | | |
| | | 2500 | | | | | E | | |
| | | 3000 | | | | | E | | |
| | | 3500 | | | | | E | | |
| | | 4000 | | | | | E | | |
| 59 | 139 | 4500 | | | | | E | | |
| | | 5000 | | | | | E | | |
| | | 5500 | | | | | E | | |
| | | 6000 | | | | | E | | |
| | | 6500 | | | | | E | | |
| | | 7000 | | | | | E | | |
| | | 9000 | | | | E | E | | |
| 62 | 144 | 2000 | | | | | E | | |
| | | 2500 | | | | | E | | |
| | | 3000 | | | | | E | | |
| | | 3500 | | | | | E | | |
| | | 4000 | | | | | E | | |

(continued)

TABLE 19 (continued)

| Temperature (°C) | Temperature (°F) | Fuel flow rate (μℓ/min) | Fuel burning characteristics: JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP)/ JP-8 (10/90) | JP-4 (HVP)/ JP-8 (50/50) | [illegible] |
|---|---|---|---|---|---|---|---|---|---|
| 62 | 144 | 4500 | | | | | E | | |
| | | 5000 | | | | | E | | |
| | | 5500 | | | | | F | | |
| | | 6000 | | | | | E | | |
| | | 6500 | | | | | E | | |
| | | 7000 | | | | | E | | |
| | | 7500 | | | | | E | | |
| | | 8000 | | | | | E | | |
| | | 8500 | | | | | E | | |
| | | 9000 | | | | | E | | |
| 66 | 150 | 900 | | | | | | E | |
| | | 1000 | | | E | | | SB | |
| | | 1250 | | | | | | SB | |
| | | 1500 | | | | | | SB | |
| | | 1750 | | | | | | SB | |
| | | 2000 | | | | | | SB | |
| | | 2500 | | | | | E | SB | |
| | | 3000 | | | | | SB | SB | |
| | | 8000 | | | E | E | | | |
| 69 | 156 | 9000 | | | E | | | | |
| 71 | 159 | 2500 | | | | | E | | |
| | | 3000 | | | | | SB | | |
| 72 | 162 | 9000 | | | E | E | | | |
| 73 | 163 | 100 | E | E | | | | | |
| | | 200 | SB | SB | | | | | |
| | | 300 | SB | SB | | | | | |
| | | 400 | SB | SB | | | | | |
| | | 1500 | | | | E | | | |
| | | 2000 | | | | E | | | |
| | | 2500 | | | | E | | | |
| | | 3000 | | | | E | | | |
| | | 3500 | | | | E | | | |
| | | 4000 | | | | E | | | |
| | | 4500 | | | | SB | | | |
| | | 8000 | | | | SB | | | |
| 76 | 169 | 1500 | | | | | E | | |
| | | 2000 | | | | | E | | |
| | | 2500 | | | | | SB | | |
| | | 9000 | | | E | | | | |

(continued)

TABLE 19 (continued)

| Temperature (°C) | Temperature (°F) | Fuel flow rate (μℓ/min) | Fuel burning characteristics JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP)/ JP-8 (10/90) | JP-4 (HVP)/ JP-8 (50/50) | AvGas |
|---|---|---|---|---|---|---|---|---|---|
| 77 | 170 | 2000 | | | | E | | | |
| | | 3000 | | | | SB | | | |
| | | 4000 | | | | SB | | | |
| 78 | 172 | 9000 | | | E | | | | |
| 79 | 175 | 600 | | | | | | E | |
| | | 700 | | | | | | SB | |
| | | 800 | | | | | | SB | |
| | | 900 | | | | | | SB | |
| | | 1000 | | | | | | SB | |
| | | 1250 | | | | | | SB | |
| | | 1500 | | | | | | SB | |
| | | 1750 | | | | | | SB | |
| | | 2000 | | | | | | SB | |
| 82 | 180 | 1500 | | | | | E | | |
| | | 2000 | | | | E | SB | | |
| | | 2500 | | | | SB | | | |
| | | 3000 | | | | SB | | | |
| 83 | 181 | 9000 | | | E | | | | |
| 86 | 187 | 9000 | | | E | | | | |
| 88 | 190 | 700 | | | | | E | | |
| | | 1000 | | | | | E | | |
| | | 1500 | | | | E | SB | | |
| | | 2000 | | | | SB | | | |
| | | 2500 | | | | SB | SB | | |
| 92 | 197 | 500 | | | | | E | | |
| | | 600 | | | | | SB | | |
| | | 700 | | | | | SB | | |
| | | 800 | | | | | SB | | |
| | | 900 | | | | | SB | | |
| | | 1000 | | | | | SB | | |

(continued)

TABLE 19 (continued)

| Temperature (°C) | Temperature (°F) | Fuel flow rate (μℓ/min) | Fuel burning characteristics: JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP)/ JP-8 (10/90) | JP-4 (HVP)/ JP-8 (50/50) | AvGas |
|---|---|---|---|---|---|---|---|---|---|
| 93 | 200 | 1500 | | | | E | | | |
| | | 2000 | | | | SB | | | |
| | | 2500 | | | | SB | | | |
| | | 3000 | | | | SB | | | |
| 98 | 208 | 500 | | | | | E | | |
| | | 700 | | | | | E | | |
| | | 800 | | | | | SB | | |
| | | 1000 | | | | | SB | | |
| | | 8000 | | | E | | | | |
| | | 8500 | | | E | | | | |
| | | 9000 | | | SB | | | | |

TABLE 20. MINIMUM FLOW RATES FOR SUSTAINED BURNING AT TEMPERATURES FROM 33°C TO 98°C (38°F TO 208°F). QUIESCENT ATMOSPHERE. ANGLE OF INCLINATION 0 DEGREE

| Temperature (°C) | Temperature (°F) | Flow rate (μℓ/min): JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP)/ JP-8 (10/90) | JP-4 (HVP)/ JP-8 (50/50) | AvGas |
|---|---|---|---|---|---|---|---|---|
| 3.3 | 38 | 3000 | 700 | | | | 6000 | |
| 10 | 50 | | | | | | 5000 | |
| 24 | 75 | 600 | 400 | | | | 2500 | |
| 28 | 82 | | | | | | | 300 |
| 38 | 100 | 400 | 400 | | | | 1250 | |
| 52 | 125 | | | | | | 1250 | |
| 66 | 150 | | | | | 3000 | 1000 | |
| 71 | 159 | | | | | 3000 | | |
| 73 | 163 | 200 | 200 | | 4500 | | | |
| 76 | 169 | | | | | 2500 | | |
| 77 | 170 | | | | 3000 | | | |
| 79 | 175 | | | | | | 700 | |
| 82 | 180 | | | | 2500 | 2000 | | |
| 88 | 190 | | | | 2000 | 1500 | | |
| 92 | 197 | | | | | 600 | | |
| 93 | 200 | | | | 2000 | | | |
| 98 | 208 | | | 9000 | | | | |

TABLE 21. IGNITABILITY OF DISPERSED FUELS, FLOWING AT SELECTED RATES, ON ALCLAD SURFACE[a]

| Fuel | Fuel flow rate (μℓ/min) | Temperature °C | Temperature °F | Fuel flow time (min)[b] | Spot dimensions (cm) Length | Spot dimensions (cm) Width | Remarks |
|---|---|---|---|---|---|---|---|
| JP-4 (LVP) | 500 | 23 | 73 | 5 | 25.0 | 25.0 | Flames flashed over the surface. No sustained burning. |
| | 600 | 23 | 73 | 5 | 27.5 | 27.5 | Flames initially flashed over the surface. Sustained burning. |
| JP-4 (HVP) | 100 | 23 | 73 | 5 | 14.0 | 14.0 | No sustained burning. The torch flame dried the surface. |
| | 200 | 23 | 73 | 5 | 18.0 | 18.0 | No sustained burning. The torch flame dried the surface. |
| | 300 | 23 | 73 | 5 | 21.0 | 21.0 | No sustained burning. The torch flame dried the surface. |
| | 400 | 23 | 73 | 5 | 23.0 | 23.0 | Sustained burning with a small flame. |
| | 500 | 23 | 73 | 5 | 25.0 | 25.0 | Sustained burning with a small flame. |
| JP-4 (HVP) | 100 | 23 | 73 | 10 | 19.0 | 19.0 | No sustained burning. The torch flame dried the surface. |
| | 200 | 23 | 73 | 10 | 23.5 | 23.5 | No sustained burning. The torch flame dried the surface. |
| | 300 | 23 | 73 | 10 | 26.5 | 26.5 | Sustained burning with a small flame. |
| | 400 | 23 | 73 | 10 | 30.5 | 30.5 | Sustained burning with a small flame. |
| JP-8 | 2750 | 82 | 180 | 1 | 9 | 23 | Ignition and transitory burning; no sustained burning. |
| | 2750 | 82 | 180 | 3 | 17 | 24 | Ignition and transitory burning; no sustained burning. |
| | 3000 | 82 | 180 | 1 | 16 | 22 | Sustained burning with a small flame. |
| | 3000 | 82 | 180 | 3 | 17 | 24 | Sustained burning with a small flame. |

[a]Single experiments were conducted under each combination of selected conditions, with the panel mounted at 0° angle of inclination.

[b]Flow time prior to exposure of the dispersing fuel to the flame of a propane torch.

# APPENDIX II

# GRAPHICAL PRESENTATION OF RESULTS

## A. Properties of Fuels

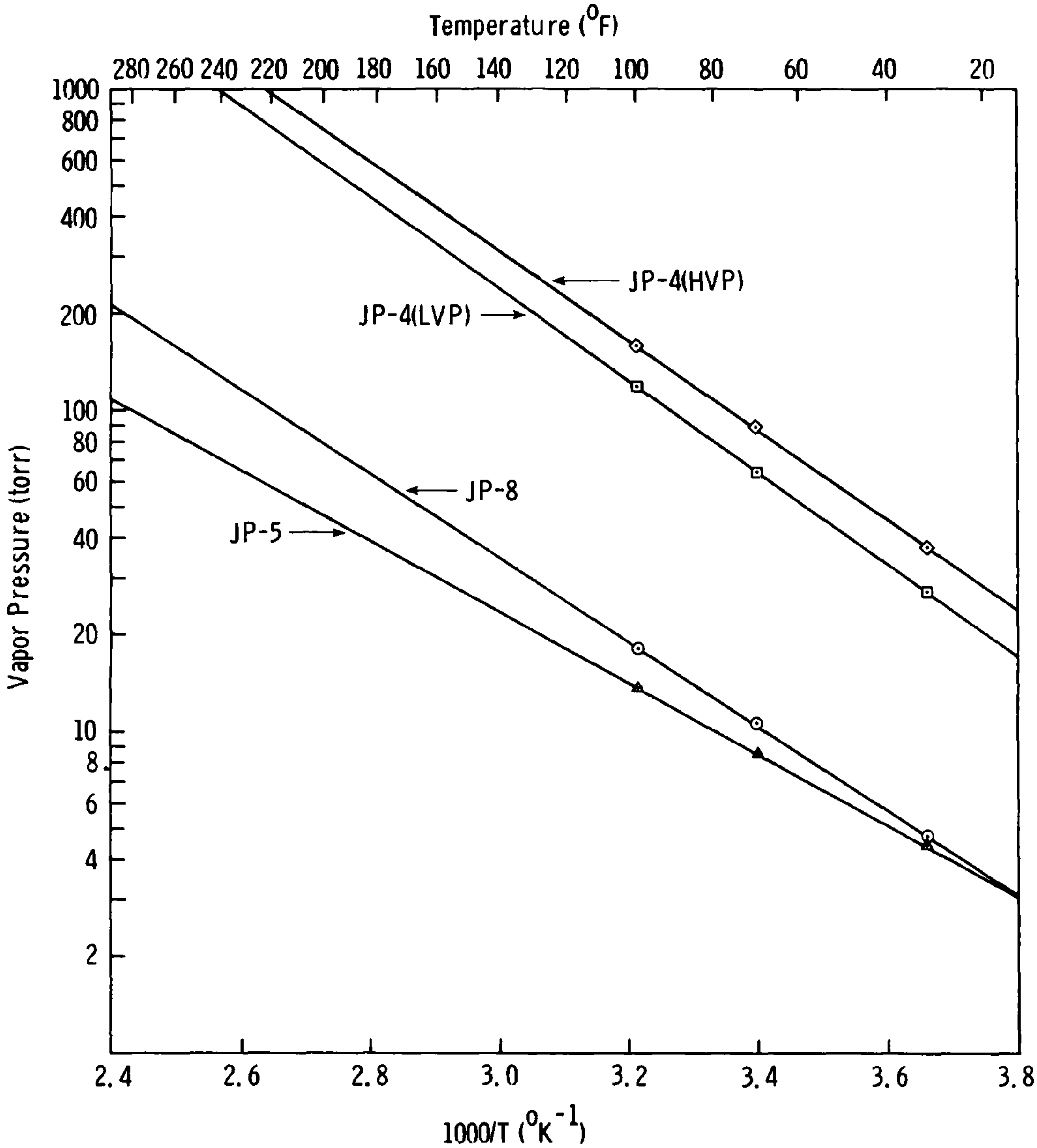



Figure 15. Vapor pressures of jet fuels.

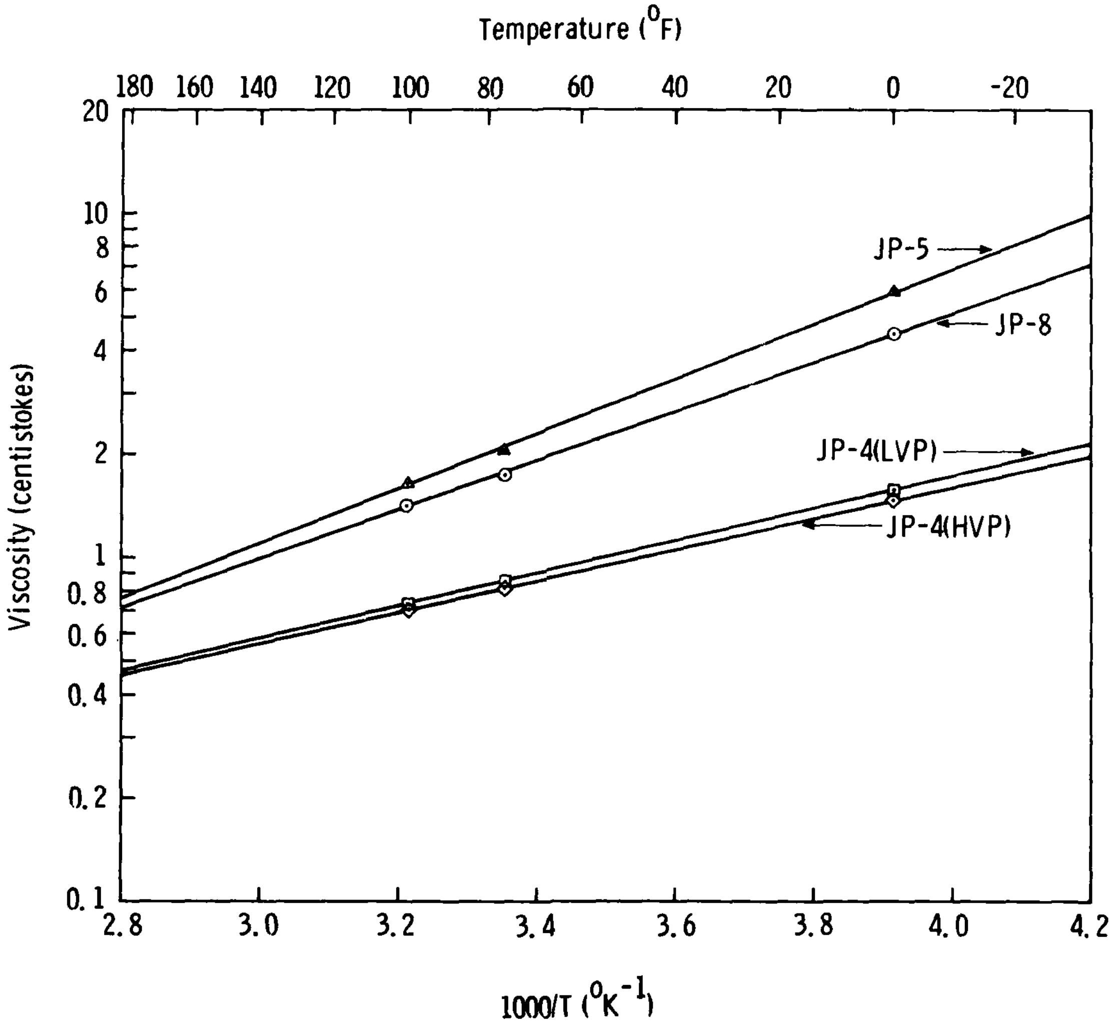



Figure 16. Viscosities of jet fuels.

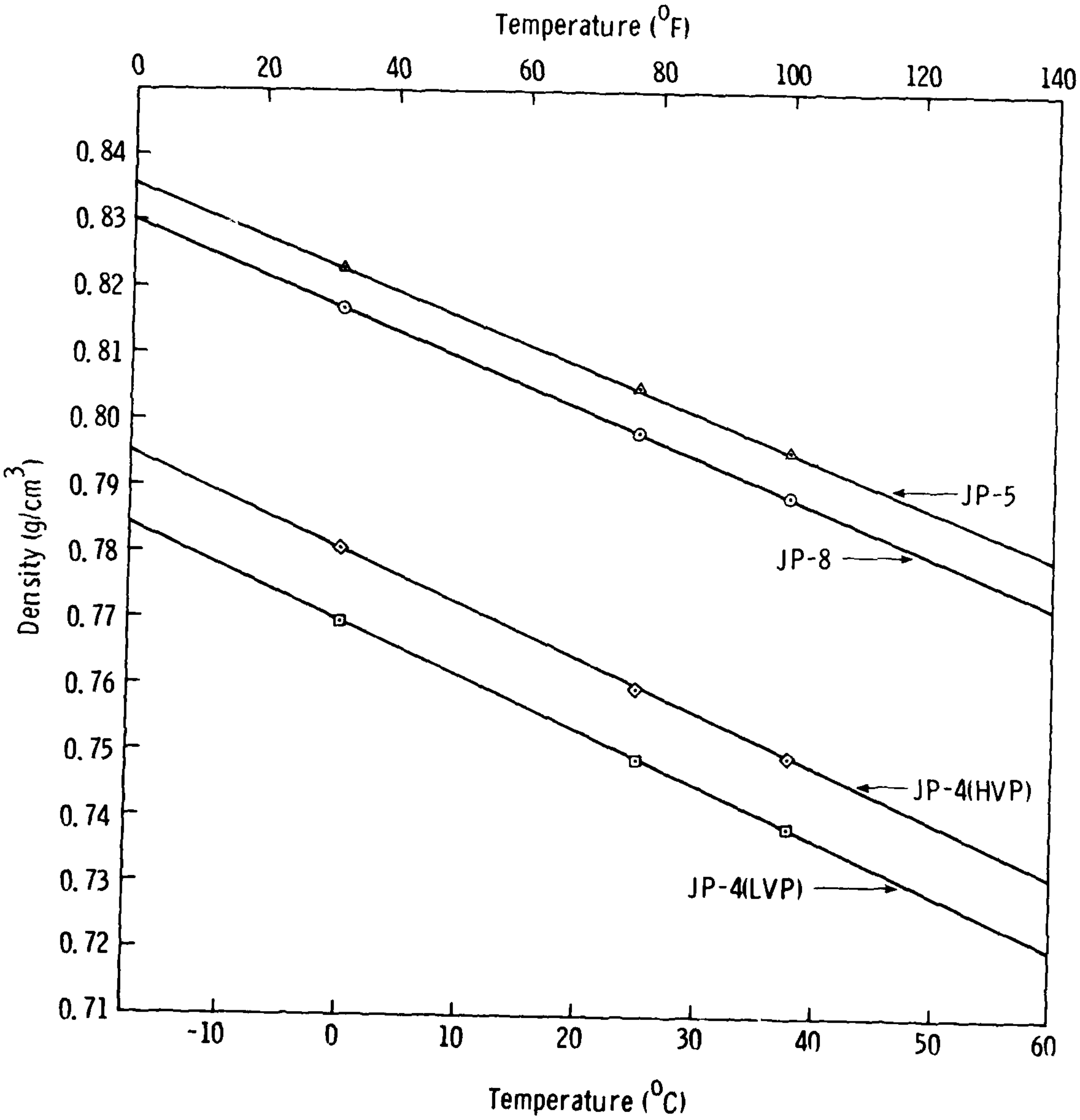



Figure 17. Densities of jet fuels.

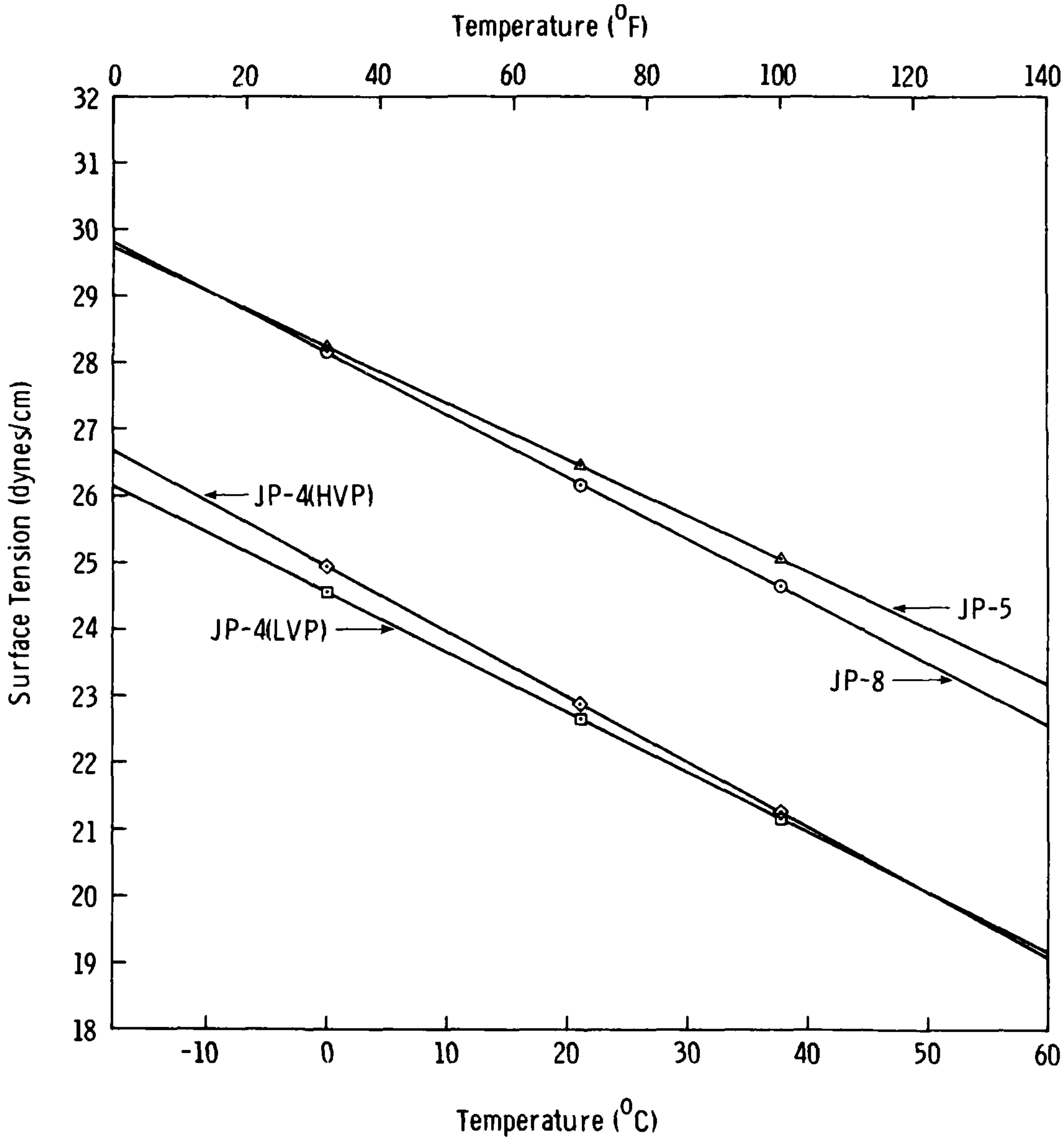



Figure 18. Surface tensions of jet fuels.

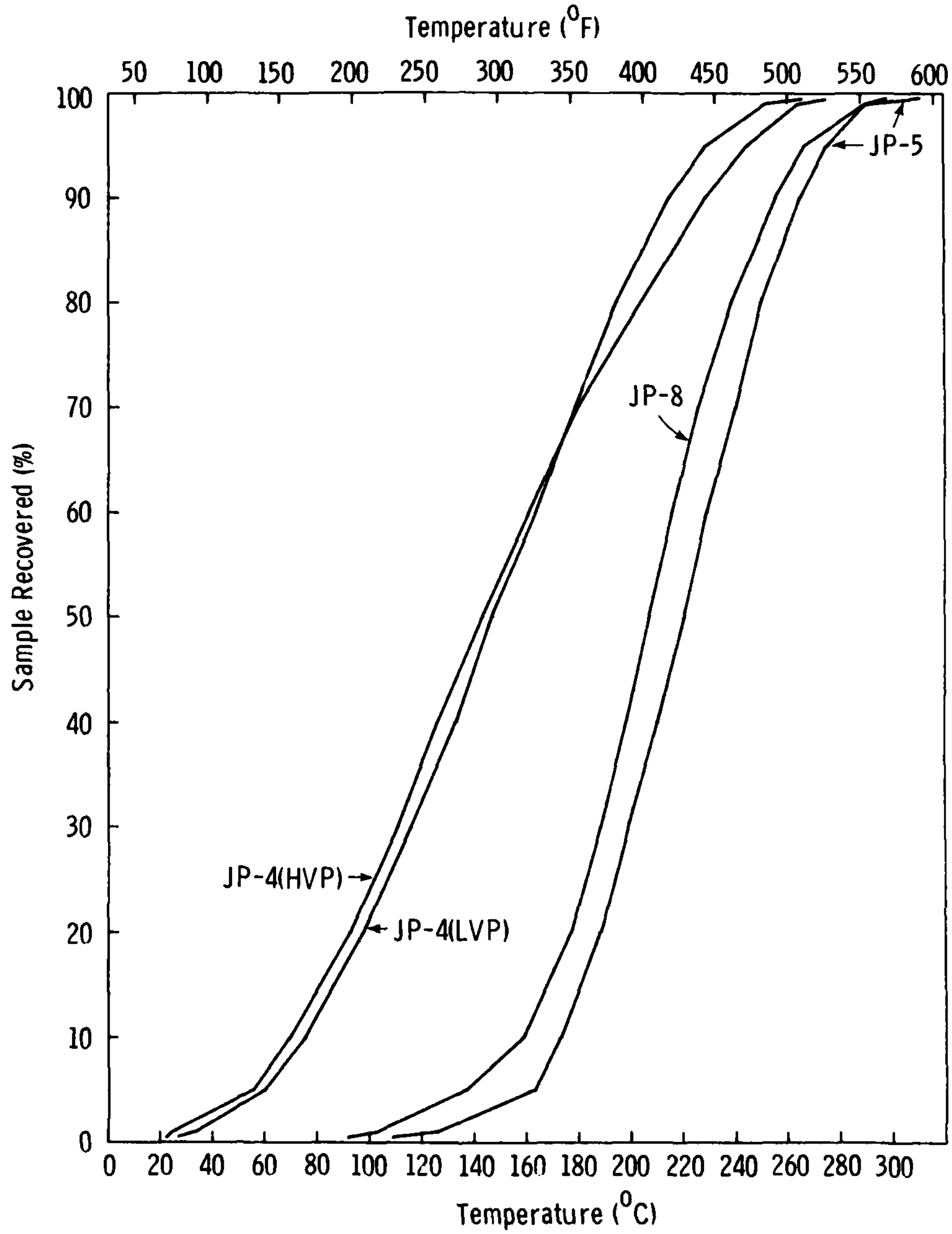



Figure 19. Simulated distillation curves of jet fuels.

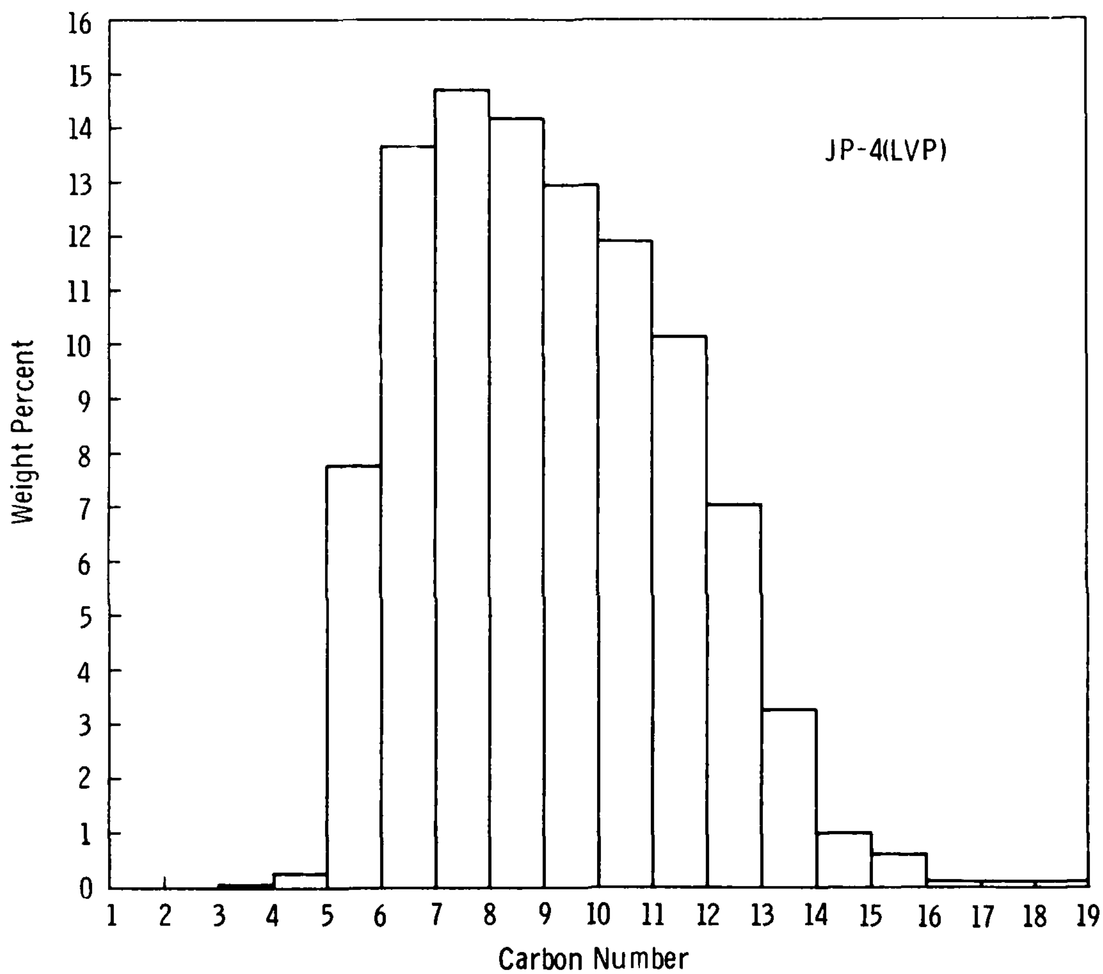



Figure 20. Distribution of hydrocarbons in JP-4(LVP), determined by simulated distillation.

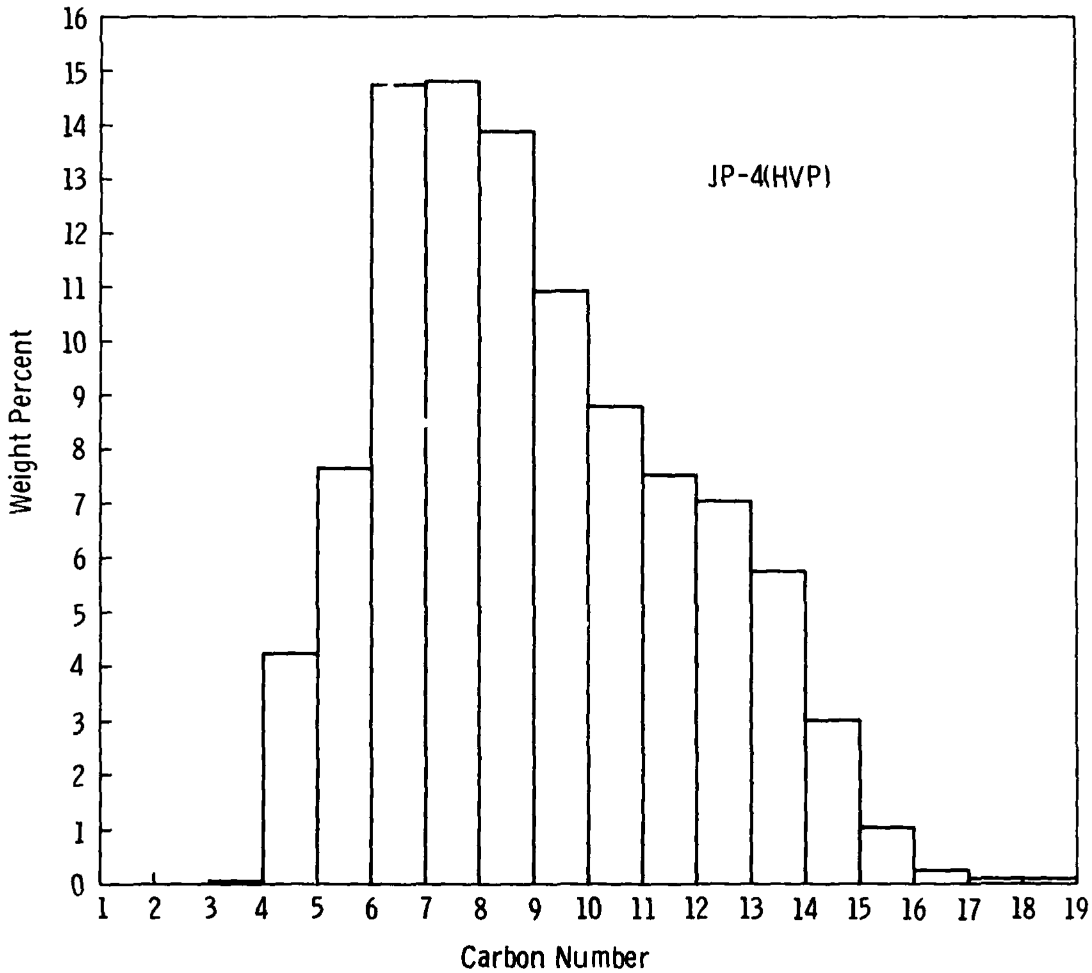



Figure 21. Distribution of hydroc rbons in JP-4(HVP), determined by simulatec distillation.

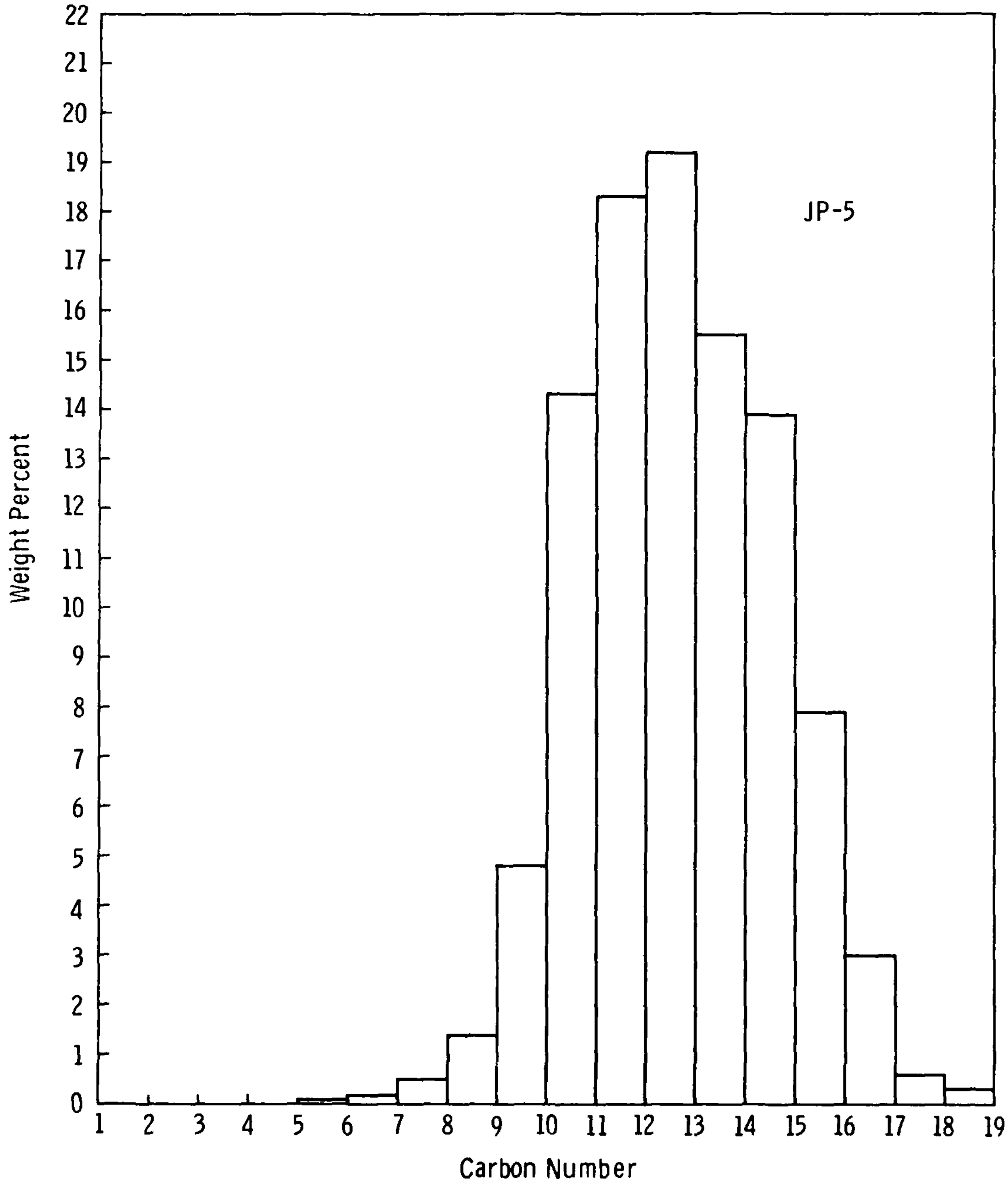



Figure 22. Distribution of hydrocarbons in JP-5, determined by simulated distillation.

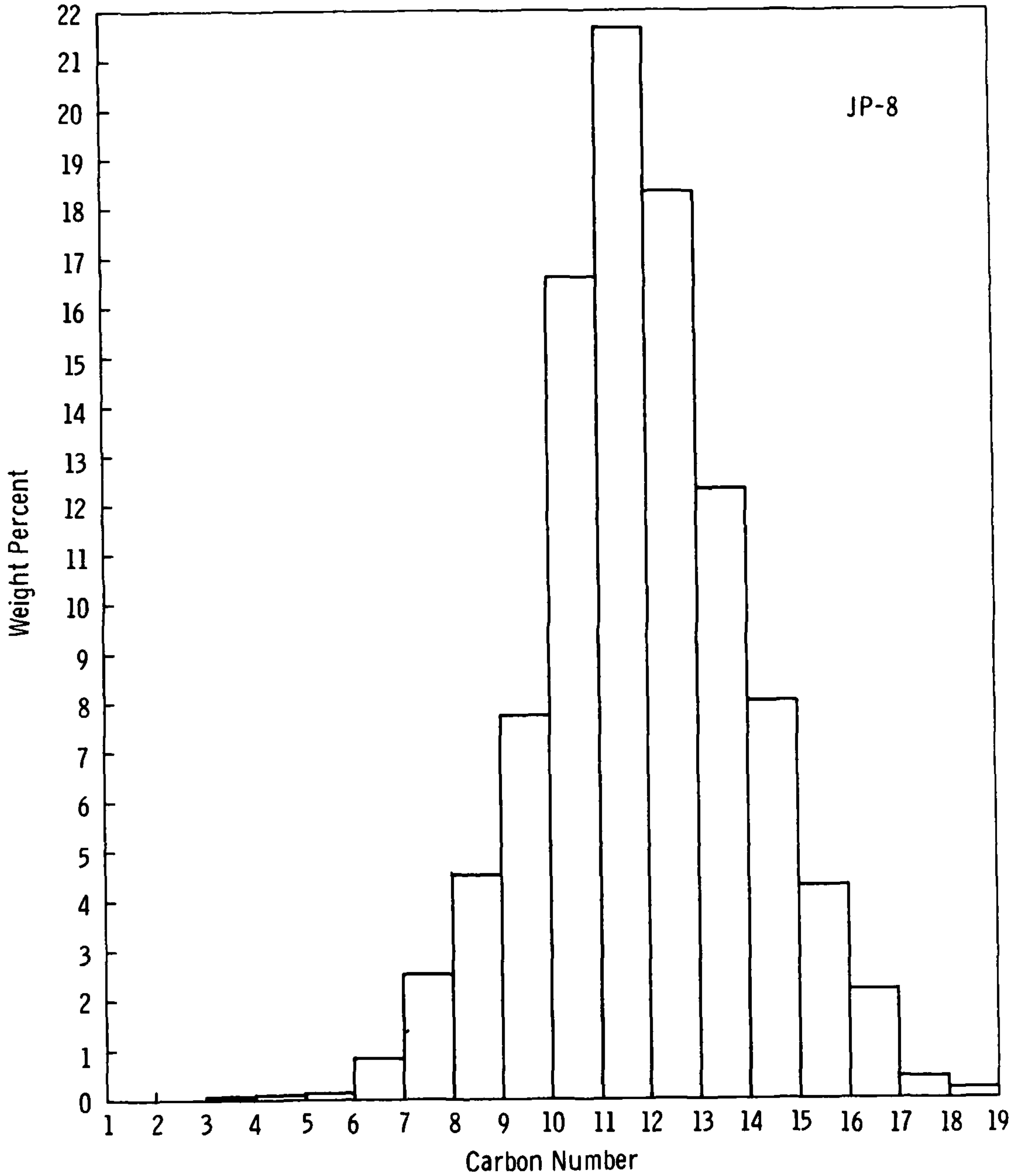



Figure 23. Distribution of hydrocarbons in JP-8, determined by simulated distillation.

## B. Surface-Dispersion of Fuels

1. Key to Figures
2. Figures

Key 1. Effect of Fuel Flow Rate (1 to 1000 μℓ/min.) at Fixed Angles of Panel Inclination (0°, 5°, 10° and 90°).[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (μℓ/min.) / Fluid | 3.3°C (38°F) None JP-4 (HVP)[b] | 3.3°C (38°F) None JP-5 | 3.3°C (38°F) None JP-8 | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-4 (LVP)[c] | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-4 (HVP) | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-5 | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-8 | 23°C (73°F) None JP-4 (HVP) | 23°C (73°F) None JP-5 | 23°C (73°F) None JP-8 | 23°C (73°F) None JP-4/JP-8[d] | 23°C (73°F) None AvGas[e] | 32°C (90°F) None JP-4 (HVP) | 32°C (90°F) None JP-5 | 32°C (90°F) None JP-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | | | | | | • (33) | | | | | | | | | |
| 0 | 5 | | | | • (27) | • (30) | • | • (36) | • (39) | | • (42) | | | | | |
| 0 | 10 | | • (25) | | • | • | • | • | • | • (41) | • | | | | • (47) | |
| 0 | 25 | | • | • (26) | • | • | • | • | • | • | • | | | | • | |
| 0 | 50 | • (24) | • | • | • | • | • | • | • | • | • | • (44) | | • (46) | • | • (48) |
| 0 | 100 | • | | • | • | • | • | • | | | • | • | • (45) | • | | • |
| 0 | 250 | | | • | • | • | • | • | | | • | | • | | | |
| 0 | 500 | | | | • | • | | • | • | | | | • | | | |
| 0 | 1000 | | | | • | • | | | • | | | | • | | | |
| 0 | 1400 | | | | | | | | | | | | • | | | |
| 5 | 10 | | | | • (28) | • (31) | • (34) | • (37) | | | | | | | | |
| 5 | 100 | | | | • | • | • | • | | | | | | | | |
| 5 | 250 | | | | • | • | | • | | | | | | | | |
| 5 | 500 | | | | • | • | | | | | | | | | | |
| 10 | 10 | | | | • (29) | • (32) | • (35) | • (38) | | | | | | | | |
| 10 | 100 | | | | • | • | • | • | | | | | | | | |
| 10 | 250 | | | | • | • | | | | | | | | | | |
| 10 | 500 | | | | • | • | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | • (43) | | | | | |
| 90 | 10 | | | | | | | | • (40) | | • | | | | | |
| 90 | 50 | | | | | | | | • | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.
[b] High vapor pressure sample.
[c] Low vapor pressure sample.
[d] JP-4/JP-8 in 10/90 volume ratio.
[e] Single experiments were conducted with AvGas[e] at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 2. Comparison of the Dispersion of Different Fuels on Alclad Surface at Fixed Flow Rates (5, 10, 25, 50, 100 and 250 $\mu\ell$/min.) and Angles of Inclination (0°, 5° and 10°).[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate ($\mu\ell$/min.) / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | 50 ● | ● | ● | ● | ● | | ● | | | | | |
| 0 | 10 | | ● | | 51 ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 25 | | ● | ● | 52 ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 50 | 49 ● | ● | ● | 53 ● | ● | ● | ● | 60 ● | ● | ● | ● | | 61 ● | ● | ● |
| 0 | 100 | ● | | ● | 54 ● | ● | ● | ● | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | 55 ● | ● | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ● | ● | | ● | ● | | | | ● | | | |
| 0 | 1000 | | | | ● | ● | | | ● | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| 5 | 10 | | | | 56 ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | 57 ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ● | | | | | | | | |
| 5 | 500 | | | | ● | ● | | | | | | | | | | |
| 10 | 10 | | | | 58 ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | 59 ● | ● | ● | ● | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ● | ● | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ● | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 3. Effect of Temperature on the Rates of Surface-Dispersion of JP-4(HVP) and JP-5 at Fixed Fuel Flow Rates (10, 25 and 50 μℓ/min.).

| Angle (deg) | Temperature / Air flow rate / Fluid — Fuel flow rate (μℓ/min.) | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | ● | ● | ● | ● | | ● | | | | | |
| 0 | 10 | | 63 ⊙ | | ● | ● | ● | ● | ● | ⊙ | ● | | | | ⊙ | |
| 0 | 25 | | 64 ⊙ | ● | ● | ● | ● | ● | ● | ⊙ | ● | | | | ⊙ | |
| 0 | 50 | 62 ⊙ | 65 ⊙ | ● | ● | ● | ● | ● | ⊙ | ⊙ | ● | ● | | ⊙ | ⊙ | ● |
| 0 | 100 | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | ● | ● | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ● | ● | | ● | ● | | | | ● | | | |
| 0 | 1000 | | | | ● | ● | | | ● | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| 5 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ● | | | | | | | | |
| 5 | 500 | | | | ● | ● | | | | | | | | | | |
| 10 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ● | ● | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ● | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 4. Effect of Temperature on the Rate of Surface-Dispersion of JP-8 at Fixed Fuel Flow Rates (50 and 100 μℓ/min.).[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (μℓ/min.) / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | • | | | | | | | | | |
| 0 | 5 | | | | • | • | • | • | • | | • | | | | | |
| 0 | 10 | | • | | • | • | • | • | • | • | • | | | | • | |
| 0 | 25 | | • | • | • | • | • | • | • | • | • | | | | • | |
| 0 | 50 | • | • | 66 ⊙ | • | • | • | • | • | • | ⊙ | • | | • | • | ⊙ |
| 0 | 100 | • | | 67 ⊙ | • | • | • | • | | | ⊙ | • | • | • | | ⊙ |
| 0 | 250 | | | • | • | • | • | • | | | • | | • | | | |
| 0 | 500 | | | | • | • | | • | • | | | | • | | | |
| 0 | 1000 | | | | • | • | | | • | | | | • | | | |
| 0 | 1400 | | | | | | | | | | | | • | | | |
| 5 | 10 | | | | • | • | • | • | | | | | | | | |
| 5 | 100 | | | | • | • | • | • | | | | | | | | |
| 5 | 250 | | | | • | • | | • | | | | | | | | |
| 5 | 500 | | | | • | • | | | | | | | | | | |
| 10 | 10 | | | | • | • | • | • | | | | | | | | |
| 10 | 100 | | | | • | • | • | • | | | | | | | | |
| 10 | 250 | | | | • | • | | | | | | | | | | |
| 10 | 500 | | | | • | • | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | • | | | | | |
| 90 | 10 | | | | | | | | • | | • | | | | | |
| 90 | 50 | | | | | | | | • | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 5. Effect of Air Flow Rate (6.1 m/sec and none) on the Rate of Surface-Dispersion of JP-4(HVP).[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (μℓ/min.) / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | 68 ⊙ | ● | ● | ⊙ | | ● | | | | | |
| 0 | 10 | | ● | | ● | 69 ⊙ | ● | ● | ⊙ | ● | ● | | | | ● | |
| 0 | 25 | | ● | ● | ● | 70 ⊙ | ● | ● | ⊙ | ● | ● | | | | ● | |
| 0 | 50 | ● | ● | ● | ● | 71 ⊙ | ● | ● | ⊙ | ● | ● | ● | | ● | ● | ● |
| 0 | 100 | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | ● | ● | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ● | 72 ⊙ | | ● | ⊙ | | | | ● | | | |
| 0 | 1000 | | | | ● | 73 ⊙ | | | ⊙ | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| 5 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ● | | | | | | | | |
| 5 | 500 | | | | ● | ● | | | | | | | | | | |
| 10 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ● | ● | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ● | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.
[b] High vapor pressure sample.
[c] Low vapor pressure sample.
[d] JP-4/JP-8 in 10/90 volume ratio.
[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 6. Effect of Air Flow Rate (6.1 m/sec and none) on the Rate of Surface-Dispersion of JP-5.[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (µl/min.) / Fluid | 3.3°C (38°F) None JP-4 (HVP)[b] | 3.3°C (38°F) None JP-5 | 3.3°C (38°F) None JP-8 | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-4 (LVP)[c] | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-4 (HVP) | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-5 | 23°C (73°F) 6.1 m/sec (20 ft/sec) JP-8 | 23°C (73°F) None JP-4 (HVP) | 23°C (73°F) None JP-5 | 23°C (73°F) None JP-8 | 23°C (73°F) None JP-4/JP-8[d] | 23°C (73°F) None AvGas[e] | 32°C (90°F) None JP-4 (HVP) | 32°C (90°F) None JP-5 | 32°C (90°F) None JP-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | | | | | | • | | | | | | | | | |
| 0 | 5 | | | | • | • | • | • | • | | • | | | | | |
| 0 | 10 | | • | | • | • | 74 ⊙ | • | • | ⊙ | • | | | | • | |
| 0 | 25 | | • | • | • | • | 75 ⊙ | • | • | ⊙ | • | | | | • | |
| 0 | 50 | • | • | • | • | • | 76 ⊙ | • | • | ⊙ | • | • | | • | • | • |
| 0 | 100 | • | | • | • | • | • | • | | | • | • | • | • | | • |
| 0 | 250 | | | • | • | • | • | • | | | • | | • | | | |
| 0 | 500 | | | | • | • | | • | • | | | | • | | | |
| 0 | 1000 | | | | • | • | | | • | | | | • | | | |
| 0 | 1400 | | | | | | | | | | | | • | | | |
| 5 | 10 | | | | • | • | • | • | | | | | | | | |
| 5 | 100 | | | | • | • | • | • | | | | | | | | |
| 5 | 250 | | | | • | • | | • | | | | | | | | |
| 5 | 500 | | | | • | • | | | | | | | | | | |
| 10 | 10 | | | | • | • | • | • | | | | | | | | |
| 10 | 100 | | | | • | • | • | • | | | | | | | | |
| 10 | 250 | | | | • | • | | | | | | | | | | |
| 10 | 500 | | | | • | • | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | • | | | | | |
| 90 | 10 | | | | | | | | • | | • | | | | | |
| 90 | 50 | | | | | | | | • | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 7. Effect of Air Flow Rate (6.1 m/sec and none) on the Rate of Surface-Dispersion of JP-8.[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (µℓ/min.) / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | • | | | | | | | | | |
| 0 | 5 | | | | • | • | • | 77 ◉ | • | | ◉ | | | | | |
| 0 | 10 | | • | | • | • | • | 78 ◉ | • | • | ◉ | | | | • | |
| 0 | 25 | | • | • | • | • | • | 79 ◉ | • | • | ◉ | | | | • | |
| 0 | 50 | • | • | • | • | • | • | 80 ◉ | • | • | ◉ | • | | • | • | • |
| 0 | 100 | • | | • | • | • | • | 81 ◉ | | | ◉ | • | • | • | | • |
| 0 | 250 | | | • | • | • | • | 82 ◉ | | | ◉ | | • | | | |
| 0 | 500 | | | | • | • | | • | • | | | | • | | | |
| 0 | 1000 | | | | • | • | | | • | | | | • | | | |
| 0 | 1400 | | | | | | | | | | | | • | | | |
| 5 | 10 | | | | • | • | • | • | | | | | | | | |
| 5 | 100 | | | | • | • | • | • | | | | | | | | |
| 5 | 250 | | | | • | • | | • | | | | | | | | |
| 5 | 500 | | | | • | • | | | | | | | | | | |
| 10 | 10 | | | | • | • | • | • | | | | | | | | |
| 10 | 100 | | | | • | • | • | • | | | | | | | | |
| 10 | 250 | | | | • | • | | | | | | | | | | |
| 10 | 500 | | | | • | • | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | • | | | | | |
| 90 | 10 | | | | | | | | • | | • | | | | | |
| 90 | 50 | | | | | | | | • | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 8. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of Jet Fuels at the Fixed Fluid Flow Rate of 10 μℓ/min.

| Angle (deg) | Temperature | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air flow rate | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | Fuel flow rate (μℓ/min.) / Fluid | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | ● | ● | ● | ● | | 89 ◉ | | | | | |
| 0 | 10 | | ● | | ◉ | ◉ | ◉ | ◉ | 87 ◉ | ● | ◉ | | | | ● | |
| 0 | 25 | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 50 | ● | ● | ● | ● | ● | ● | ● | ◉ | ● | ● | ● | | ● | ● | ● |
| 0 | 100 | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | ● | ● | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ● | ● | | ● | ● | | | | ● | | | |
| 0 | 1000 | | | | ● | ● | | | ● | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| | | | | | 83 | 84 | 85 | 86 | | | | | | | | |
| 5 | 10 | | | | ◉ | ◉ | ◉ | ◉ | | | | | | | | |
| 5 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ● | | | | | | | | |
| 5 | 500 | | | | ● | ● | | | | | | | | | | |
| 10 | 10 | | | | ◉ | ◉ | ◉ | ◉ | | | | | | | | |
| 10 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ● | ● | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ◉ | | | | | |
| 90 | 10 | | | | | | | | ◉ | | ◉ 90 | | | | | |
| 90 | 50 | | | | | | | | ◉ 88 | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 9. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of Jet Fuels at the Fixed Fluid Flow Rate of 100 μℓ/min.[a]

| Angle (deg) | Temperature / Fuel flow rate (μℓ/min.) / Air flow rate / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air flow rate | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | Fluid | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | ● | ● | ● | ● | | ● | | | | | |
| 0 | 10 | | ● | | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 25 | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 50 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● |
| 0 | 100 | ● | | ● | ⊙ | ⊙ | ⊙ | ⊙ | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | ● | ● | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ● | ● | | ● | ● | | | | ● | | | |
| 0 | 1000 | | | | ● | ● | | | ● | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| | | | | | 91 | 92 | 93 | 94 | | | | | | | | |
| 5 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | ⊙ | ⊙ | ⊙ | ⊙ | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ● | | | | | | | | |
| 5 | 500 | | | | ● | ● | | | | | | | | | | |
| 10 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | ⊙ | ⊙ | ⊙ | ⊙ | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ● | ● | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ● | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 10. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of JP-4(LVP) and JP-4(HVP) at the Fixed Fluid Flow Rate of 250 $\mu\ell$/min.[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate ($\mu\ell$/min.) / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | ● | ● | ● | ● | | ● | | | | | |
| 0 | 10 | | ● | | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 25 | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 50 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● |
| 0 | 100 | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | ◉ | ◉ | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ● | ● | | ● | ● | | | | ● | | | |
| 0 | 1000 | | | | ● | ● | | | ● | | | | ● | | | |
| 0 | 1400 | | | | | | | | | | | | ● | | | |
| | | | | | 95 | 96 | | | | | | | | | | |
| 5 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | | | | ◉ | ◉ | | ● | | | | | | | | |
| 5 | 500 | | | | ● | ● | | | | | | | | | | |
| 10 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 250 | | | | ◉ | ◉ | | | | | | | | | | |
| 10 | 500 | | | | ● | ● | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ● | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 11. Effect of the Panel Angle of Inclination on the Rates of Surface-Dispersion of JP-4(LVP) and JP-4(HVP) at the Fixed Fluid Flow Rate of 500 μℓ/min.[a]

| Angle (deg) | Temperature / Air flow rate / Fuel flow rate (μℓ/min.) / Fluid | 3.3°C (38°F) | | | 23°C (73°F) | | | | | | | | | 32°C (90°F) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | | | 6.1 m/sec (20 ft/sec) | | | | None | | | | | None | | |
| | | JP-4 (HVP)[b] | JP-5 | JP-8 | JP-4 (LVP)[c] | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (HVP) | JP-5 | JP-8 | JP-4/JP-8[d] | AvGas[e] | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | | | | ● | | | | | | | | | |
| 0 | 5 | | | | ● | ● | ● | ● | ● | | ● | | | | | |
| 0 | 10 | | ● | | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 25 | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | |
| 0 | 50 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● |
| 0 | 100 | ● | | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | | ● |
| 0 | 250 | | | ● | ● | ● | ● | ● | | | ● | | ● | | | |
| 0 | 500 | | | | ◉ | ◉ | | ● | ● | | | | ● | | | |
| 0 | 1000 | | | | ● | ● | | | ● | | | | ● | | | |
| 0 | 1400 | | | | 97 | 98 | | | | | | | ● | | | |
| 5 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | | | | ● | ● | | ● | | | | | | | | |
| 5 | 500 | | | | ◉ | ◉ | | | | | | | | | | |
| 10 | 10 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 100 | | | | ● | ● | ● | ● | | | | | | | | |
| 10 | 250 | | | | ● | ● | | | | | | | | | | |
| 10 | 500 | | | | ◉ | ◉ | | | | | | | | | | |
| 90 | 5 | | | | | | | | | | ● | | | | | |
| 90 | 10 | | | | | | | | ● | | ● | | | | | |
| 90 | 50 | | | | | | | | ● | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

[d] JP-4/JP-8 in 10/90 volume ratio.

[e] Single experiments were conducted with AvGas at each flow rate. Triplicate experiments were conducted with the other fluids under all experimental conditions.

Key 12. Effects of Fuel Flow Rate (10 to 500 $\mu\ell$/min.) on the Rates of Surface-Dispersion of Jet Fuels on a Horizontally Mounted, Polyurethane Latex-Coated Panel.[a]

| Angle (deg) | Fuel flow rate ($\mu\ell$/min.) / Panel / Fluid | Alclad | | | | Unclad aluminum alloy | | | | Polyurethane latex-coated surface | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4 (LVP)[b] | JP-4 (HVP)[c] | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | ● | | | | | | | | | |
| 0 | 5 | ● | ● | ● | ● | | | | | | | 101 | |
| 0 | 10 | ● | ● | ● | ● | | | | | | | ● | 102 |
| 0 | 25 | ● | ● | ● | ● | | | | | | | ● | ● |
| 0 | 50 | ● | ● | ● | ● | | | | | 99 | 100 | ● | ● |
| 0 | 100 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| 0 | 250 | ● | ● | ● | ● | | | | | ● | ● | | |
| 0 | 500 | ● | ● | | ● | | | | | ● | ● | | |
| 0 | 1000 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | ● | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

Key 13. Comparison of the Dispersion of Different Fuels on Unclad Aluminum Alloy and on Polyurethane Latex-Coated Surface.[a]

| Angle (deg) | Panel / Fuel flow rate (μℓ/min.) / Fluid | Alclad | | | | Unclad aluminum alloy | | | | Polyurethane latex-coated surface | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4 (LVP)[b] | JP-4 (HVP)[c] | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | ● | | | | | | | | | |
| 0 | 5 | ● | ● | ● | ● | | | | | | | | |
| 0 | 10 | ● | ● | ● | ● | | | | | | | ● | |
| 0 | 25 | ● | ● | ● | ● | | | | | | | ● | ● |
| 0 | 50 | ● | ● | ● | ● | 103 | | | | 104 | | ● | ● |
| 0 | 100 | ● | ● | ● | ● | ◉ | ◉ | ◉ | ◉ | ◉ | ◉ | ◉ | ◉ |
| 0 | 250 | ● | ● | ● | ● | | | | | ● | ● | | |
| 0 | 500 | ● | ● | | ● | | | | | ● | ● | | |
| 0 | 1000 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | ● | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

Key 14. Effect of Panel Surface Composition (Alclad vs. Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-5 at the Fixed Fluid Flow Rates of 10 and 25 μℓ/min.[a]

| Angle (deg) | Fuel flow rate (μℓ/min.) / Panel / Fluid | Alclad | | | | Unclad aluminum alloy | | | | Polyurethane latex-coated surface | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4 (LVP)[b] | JP-4 (HVP)[c] | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | • | | | | | | | | | |
| 0 | 5 | • | • | • | • | | | | | | | | |
| 0 | 10 | • | • | ⊙ | • | | 105 | | | | | ⊙ | |
| 0 | 25 | • | • | ⊙ | • | | 106 | | | | | ⊙ | • |
| 0 | 50 | • | • | • | • | | | | | | | • | • |
| 0 | 100 | • | • | • | • | • | • | • | • | • | • | • | • |
| 0 | 250 | • | • | • | • | | | | | • | • | | |
| 0 | 500 | • | • | | • | | | | | • | • | | |
| 0 | 1000 | • | • | | | | | | | | | | |
| 5 | 10 | • | • | • | • | | | | | | | | |
| 5 | 100 | • | • | • | • | | | | | | | | |
| 5 | 250 | • | • | | • | | | | | | | | |
| 5 | 500 | • | • | | | | | | | | | | |
| 5 | 10 | • | • | • | • | | | | | | | | |
| 5 | 100 | • | • | • | • | | | | | | | | |
| 5 | 250 | • | • | | | | | | | | | | |
| 5 | 500 | • | • | | | | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

Key 15. Effect of Panel Surface Composition (Alclad vs. Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-8 at the Fixed Fluid Flow Rates of 25 and 50 μℓ/min.[a]

| Angle (deg) | Panel: / Fuel flow rate (μℓ/min.) / Fluid: | Alclad JP-4 (LVP)[b] | Alclad JP-4 (HVP)[c] | Alclad JP-5 | Alclad JP-8 | Unclad aluminum alloy JP-4 (LVP) | Unclad aluminum alloy JP-4 (HVP) | Unclad aluminum alloy JP-5 | Unclad aluminum alloy JP-8 | Polyurethane latex-coated surface JP-4 (LVP) | Polyurethane latex-coated surface JP-4 (HVP) | Polyurethane latex-coated surface JP-5 | Polyurethane latex-coated surface JP-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | | | ● | | | | | | | | | |
| 0 | 5 | ● | ● | ● | ● | | | | | | | | |
| 0 | 10 | ● | ● | ● | ● | | | | 107 | | | ● | |
| 0 | 25 | ● | ● | ● | ◉ | | | | | | | ● | ◉ |
| 0 | 50 | ● | ● | ● | ◉ | | | | 108 | | | ● | ◉ |
| 0 | 100 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| 0 | 250 | ● | ● | ● | ● | | | | | ● | ● | | |
| 0 | 500 | ● | ● | | ● | | | | | ● | ● | | |
| 0 | 1000 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | ● | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

Key 16. Effect of Panel Surface Composition (Alclad, Unclad Aluminum Alloy and Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-4(LVP) and JP-4(HVP) at the Fixed Fluid Flow Rate of 100 μℓ/min.[a]

| Angle (deg) | Panel / Fuel flow rate (μℓ/min.) / Fluid | Alclad | | | | Unclad aluminum alloy | | | | Polyurethane latex-coated surface | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4 (LVP)[b] | JP-4 (HVP)[c] | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | ● | | | | | | | | | |
| 0 | 5 | ● | ● | ● | ● | | | | | | | | |
| 0 | 10 | ● | ● | ● | ● | | | | | | | ● | |
| 0 | 25 | ● | ● | ● | ● | | | | | | | ● | ● |
| 0 | 50 | ● | ● | ● | ● | | | | | | | ● | ● |
| 0 | 100 | ⊙ | ⊙ | ● | ● | ⊙ | 109 ⊙ 110 | ● | ● | ⊙ | ⊙ | ● | ● |
| 0 | 250 | ● | ● | ● | ● | | | | | ● | ● | | |
| 0 | 500 | ● | ● | | ● | | | | | ● | ● | | |
| 0 | 1000 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | ● | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.

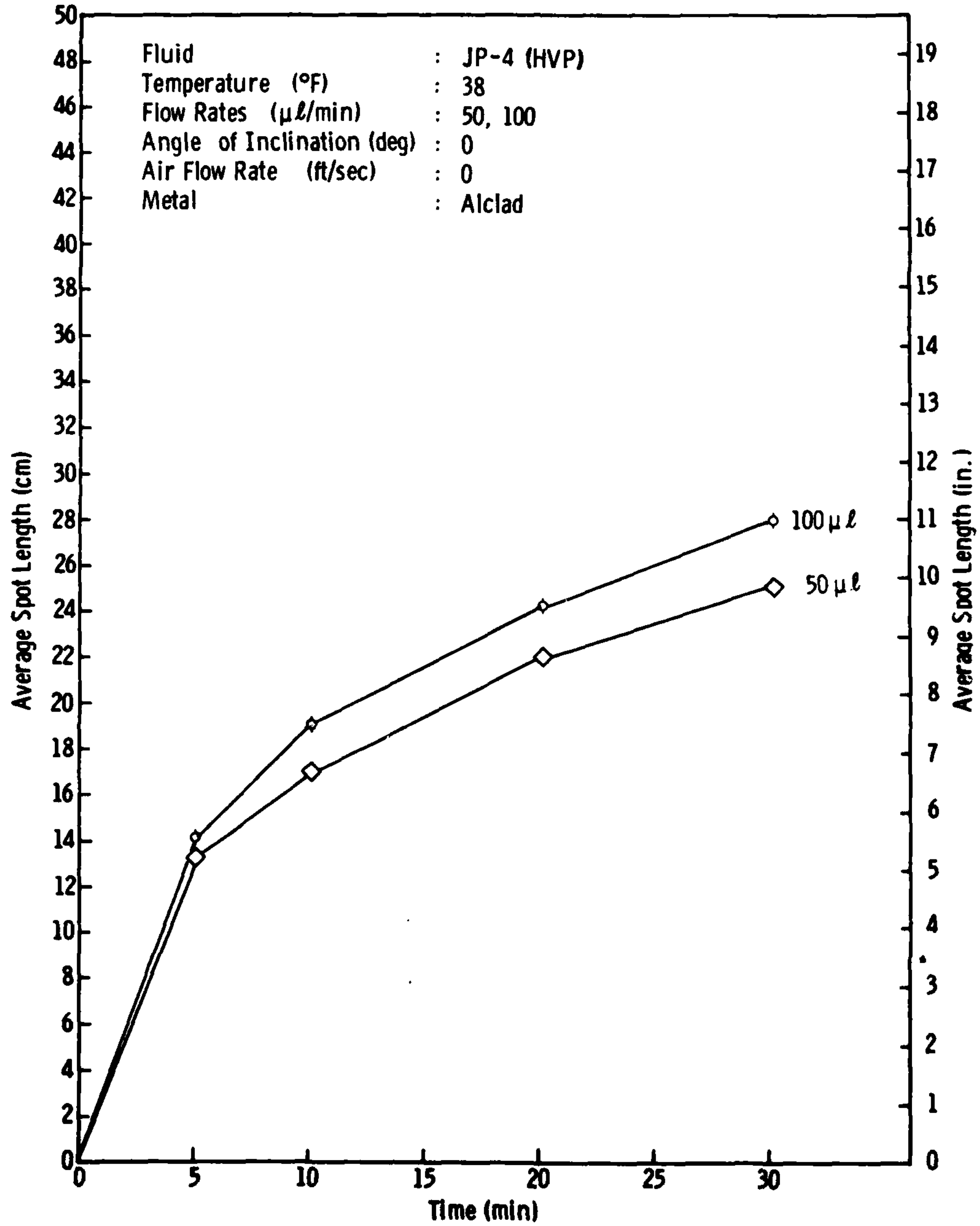
Key 17. Effect of Panel Surface Composition (Alclad, Unclad Aluminum Alloy and Polyurethane Latex Coating) on the Rates of Surface-Dispersion of JP-5 and JP-8 at the Fixed Fluid Flow Rate of 100 $\mu\ell$/min.[a]

| Angle (deg) | Panel / Fuel flow rate ($\mu\ell$/min.) / Fluid | Alclad | | | | Unclad aluminum alloy | | | | Polyurethane latex-coated surface | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JP-4 (LVP)[b] | JP-4 (HVP)[c] | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 | JP-4 (LVP) | JP-4 (HVP) | JP-5 | JP-8 |
| 0 | 1 | | | ● | | | | | | | | | |
| 0 | 5 | ● | ● | ● | ● | | | | | | | | |
| 0 | 10 | ● | ● | ● | ● | | | | | | | ● | |
| 0 | 25 | ● | ● | ● | ● | | | | | | | ● | ● |
| 0 | 50 | ● | ● | ● | c | | 111 | | | | | ● | ● |
| 0 | 100 | ● | ● | ⊙ | ⊙ | ● | ● | ⊙ | ⊙ | ● | ● | ⊙ | ⊙ |
| 0 | 250 | ● | ● | ● | ● | | 112 | | | ● | ● | | |
| 0 | 500 | ● | ● | | ● | | | | | ● | ● | | |
| 0 | 1000 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | ● | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |
| 5 | 10 | ● | ● | ● | ● | | | | | | | | |
| 5 | 100 | ● | ● | ● | ● | | | | | | | | |
| 5 | 250 | ● | ● | | | | | | | | | | |
| 5 | 500 | ● | ● | | | | | | | | | | |

[a] Measurement time was 30 min. for all experiments shown in this table.

[b] High vapor pressure sample.

[c] Low vapor pressure sample.



Fluid : JP-4 (HVP)
Temperature (°F) : 38
Flow Rates (μℓ/min) : 50, 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
100 μℓ
50 μℓ
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
0
5
10
15
20
25
30


Figure 24.

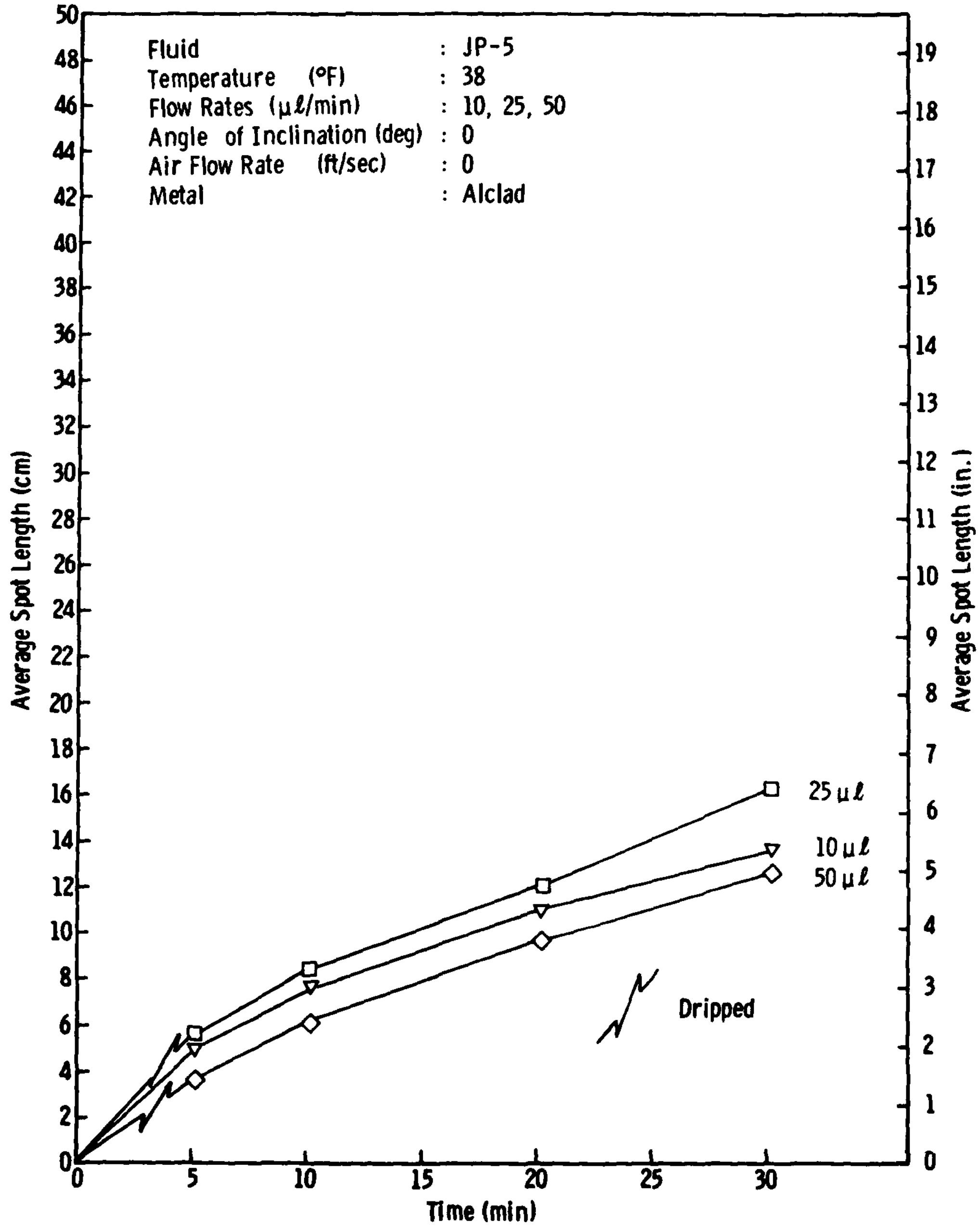
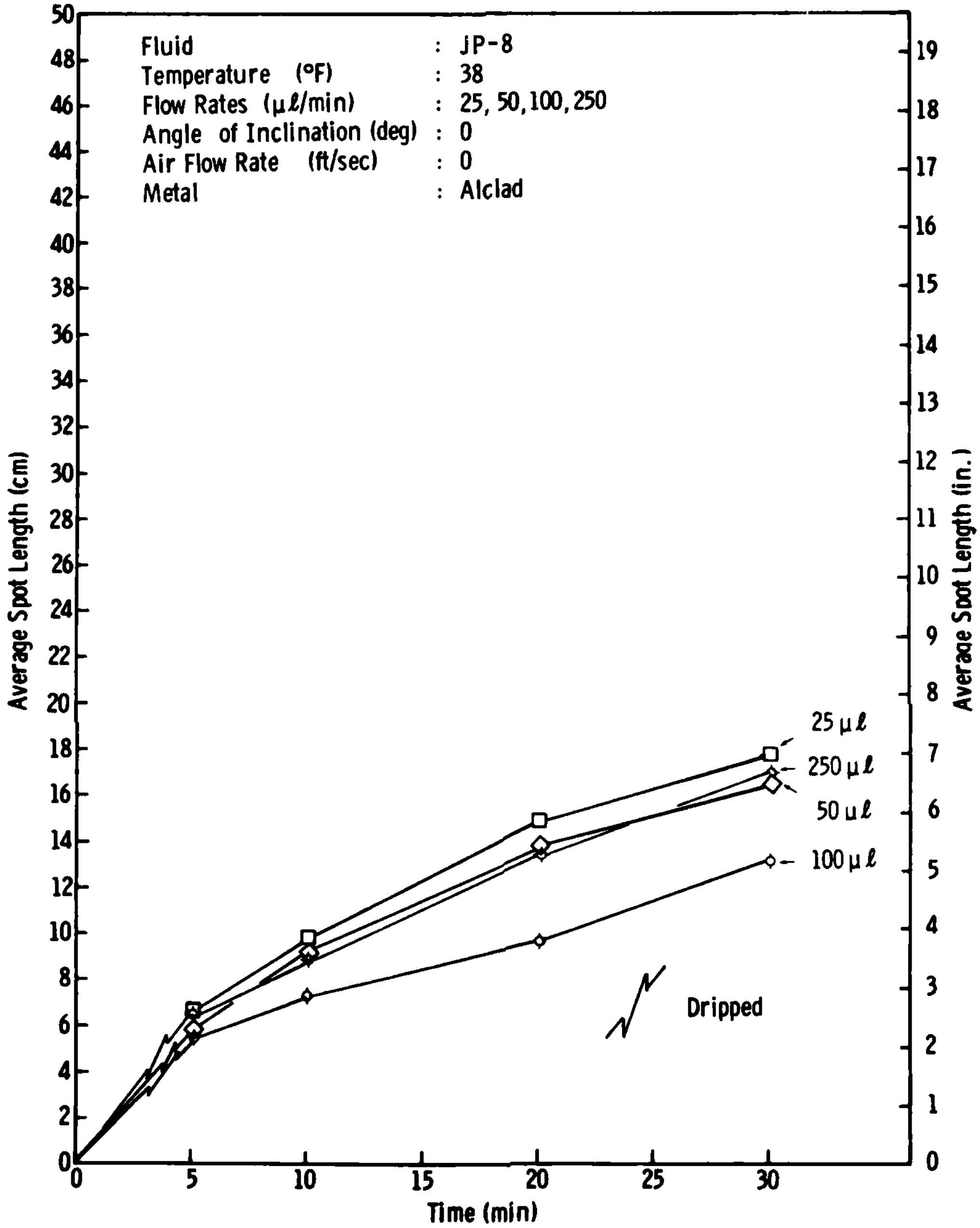
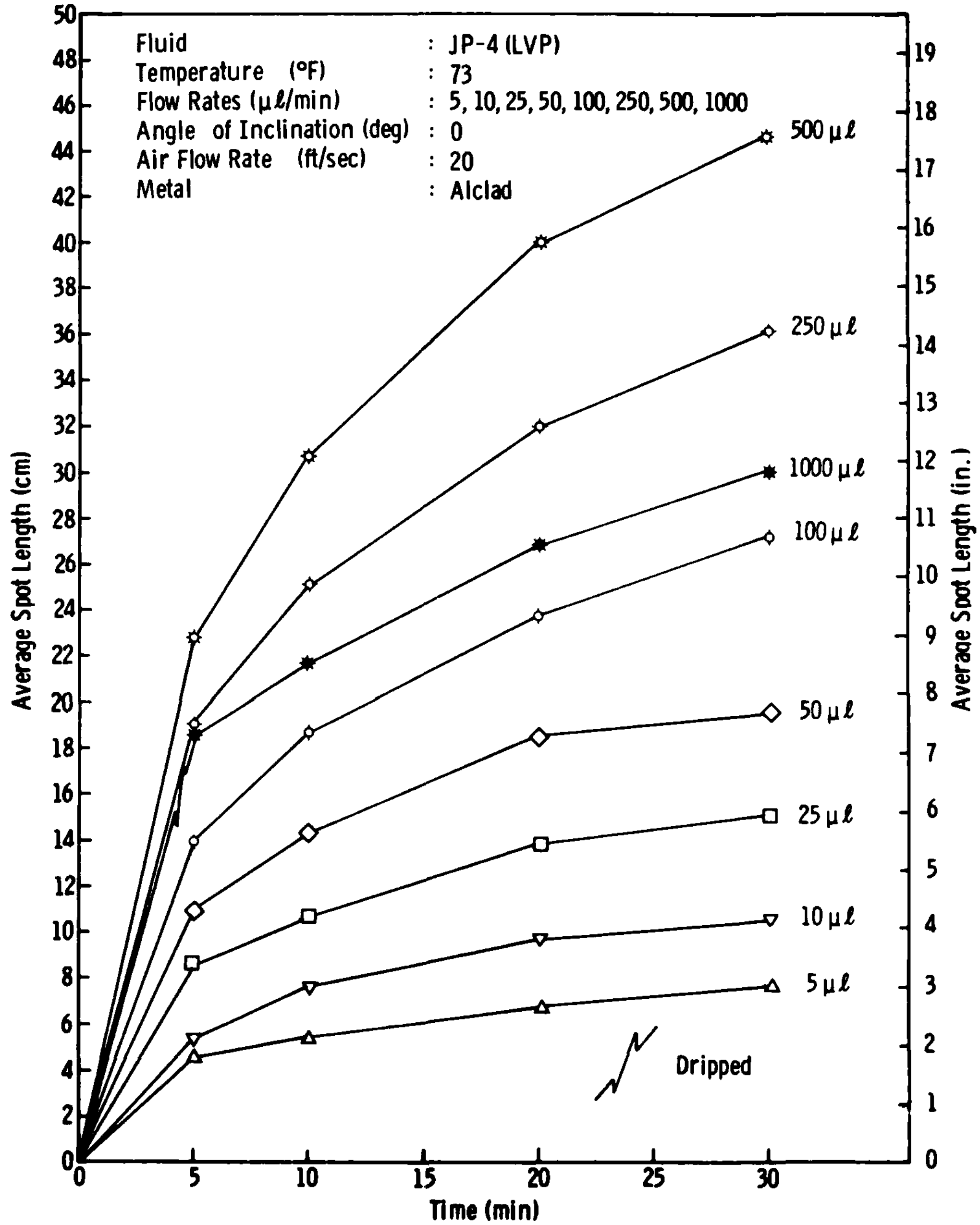

Fluid : JP-5
Temperature (°F) : 38
Flow Rates (μℓ/min) : 10, 25, 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
25 μℓ
10 μℓ
50 μℓ
Dripped
0
5
10
15
20
25
30

Figure 25.



Fluid : JP-8
Temperature (°F) : 38
Flow Rates (µℓ/min) : 25, 50, 100, 250
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
25 µℓ
250 µℓ
50 µℓ
100 µℓ
Dripped


Figure 26.



Fluid : JP-4 (LVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 5, 10, 25, 50, 100, 250, 500, 1000
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
500 μℓ
250 μℓ
1000 μℓ
100 μℓ
50 μℓ
25 μℓ
10 μℓ
5 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 27.

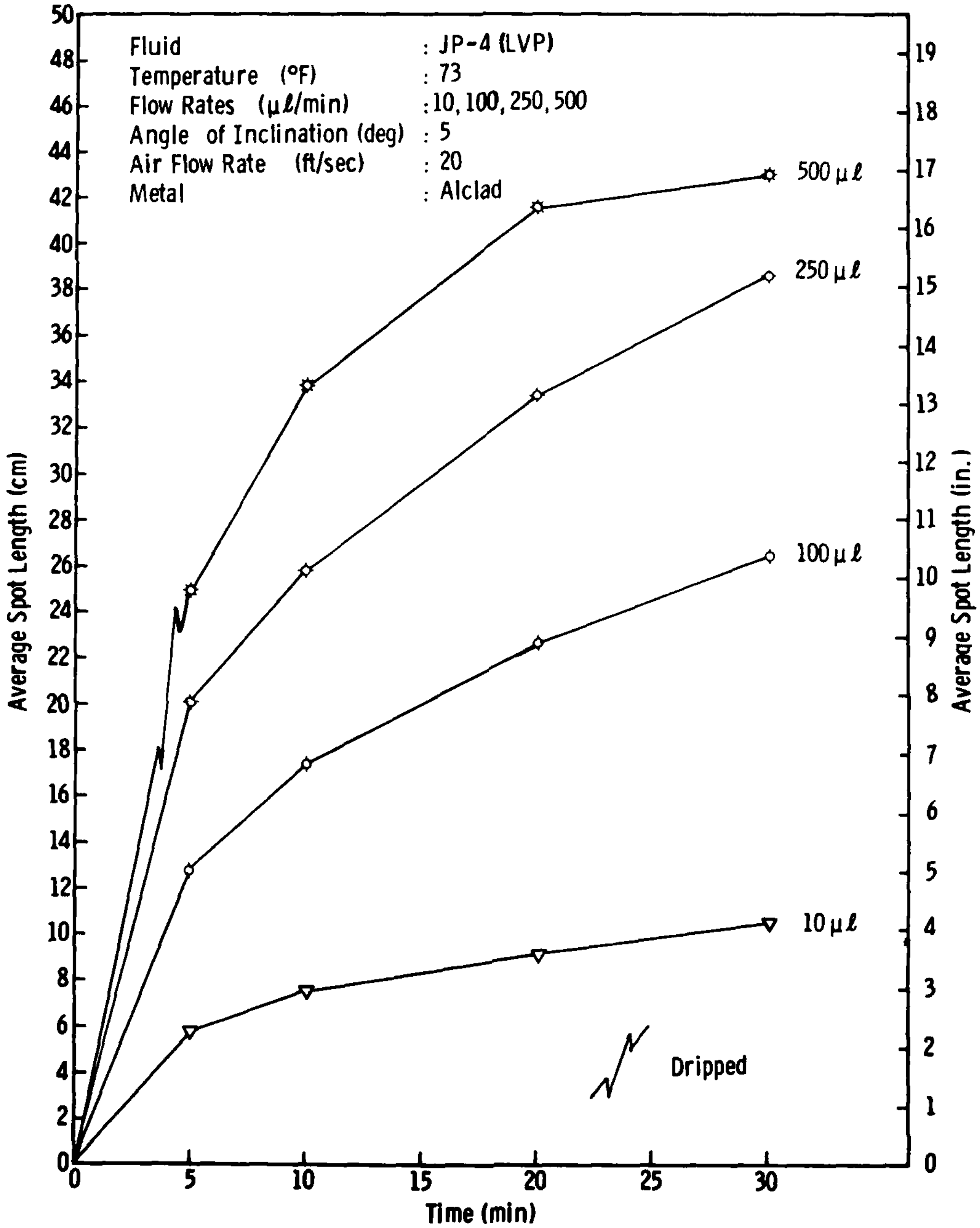

Fluid : JP-4 (LVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 10, 100, 250, 500
Angle of Inclination (deg) : 5
Air Flow Rate (ft/sec) : 20
Metal : Alclad
500 μℓ
250 μℓ
100 μℓ
10 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 28.

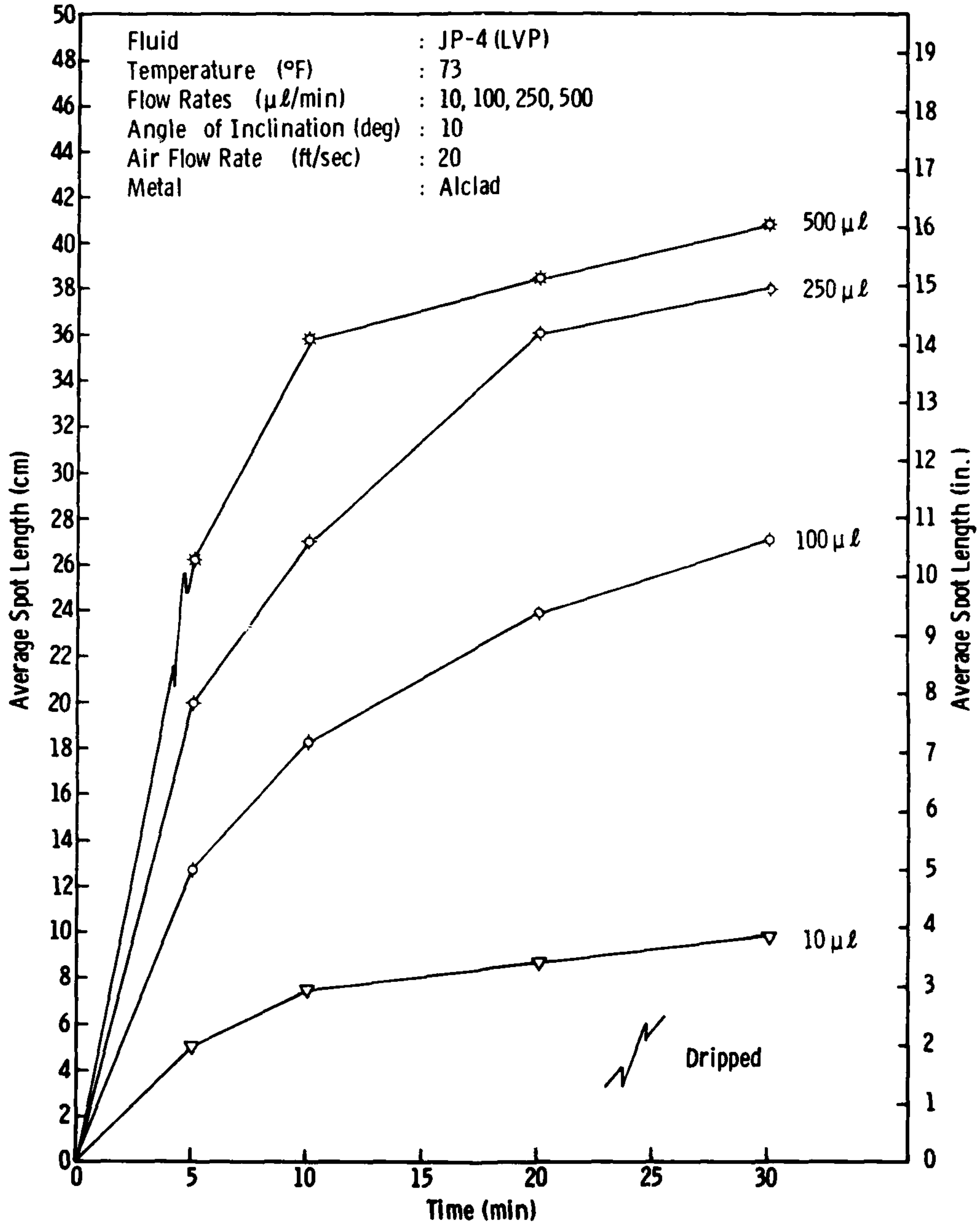
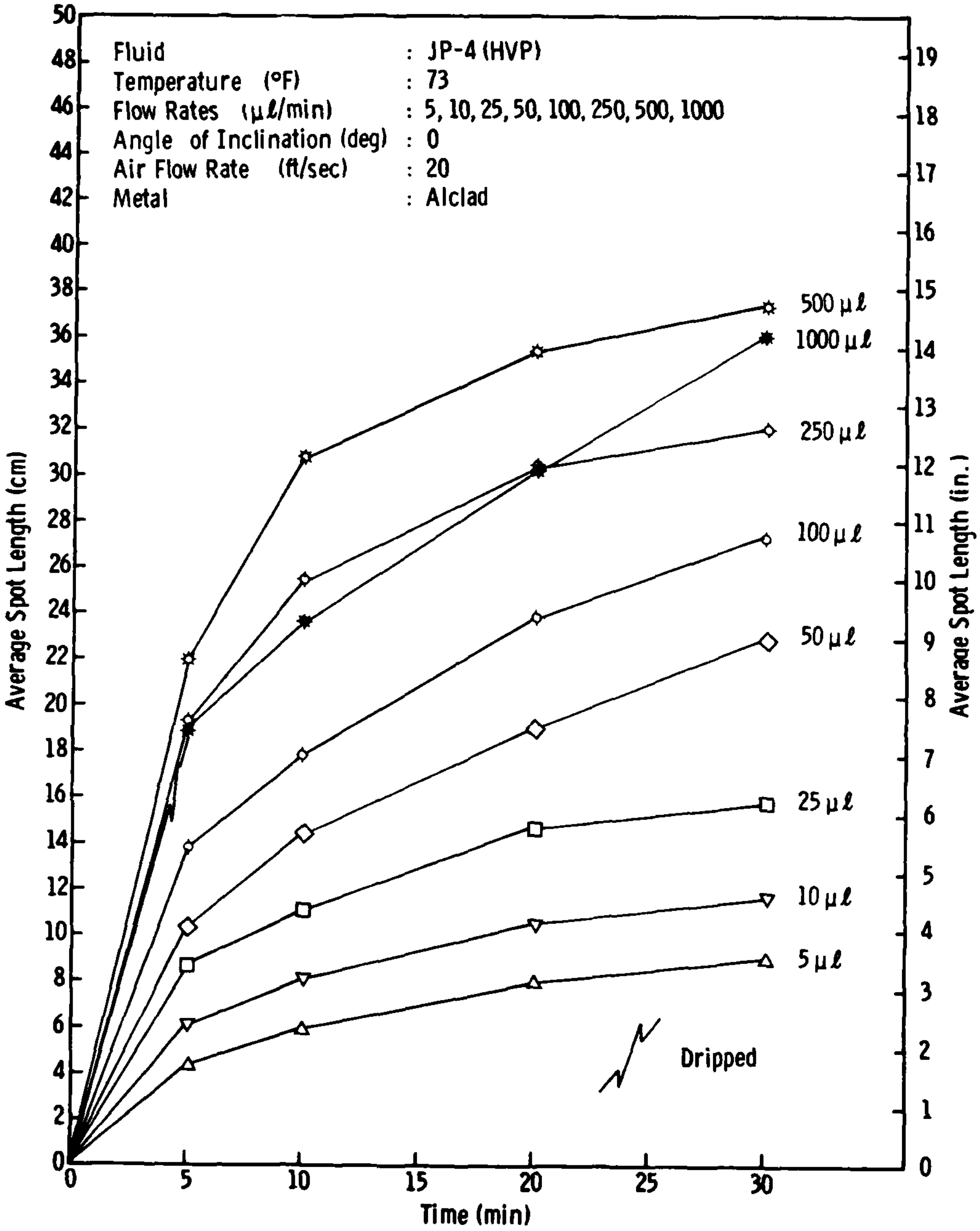

Fluid : JP-4 (LVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 10, 100, 250, 500
Angle of Inclination (deg) : 10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
500 μℓ
250 μℓ
100 μℓ
10 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 29.



Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 5, 10, 25, 50, 100, 250, 500, 1000
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
500 μℓ
1000 μℓ
250 μℓ
100 μℓ
50 μℓ
25 μℓ
10 μℓ
5 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 30.

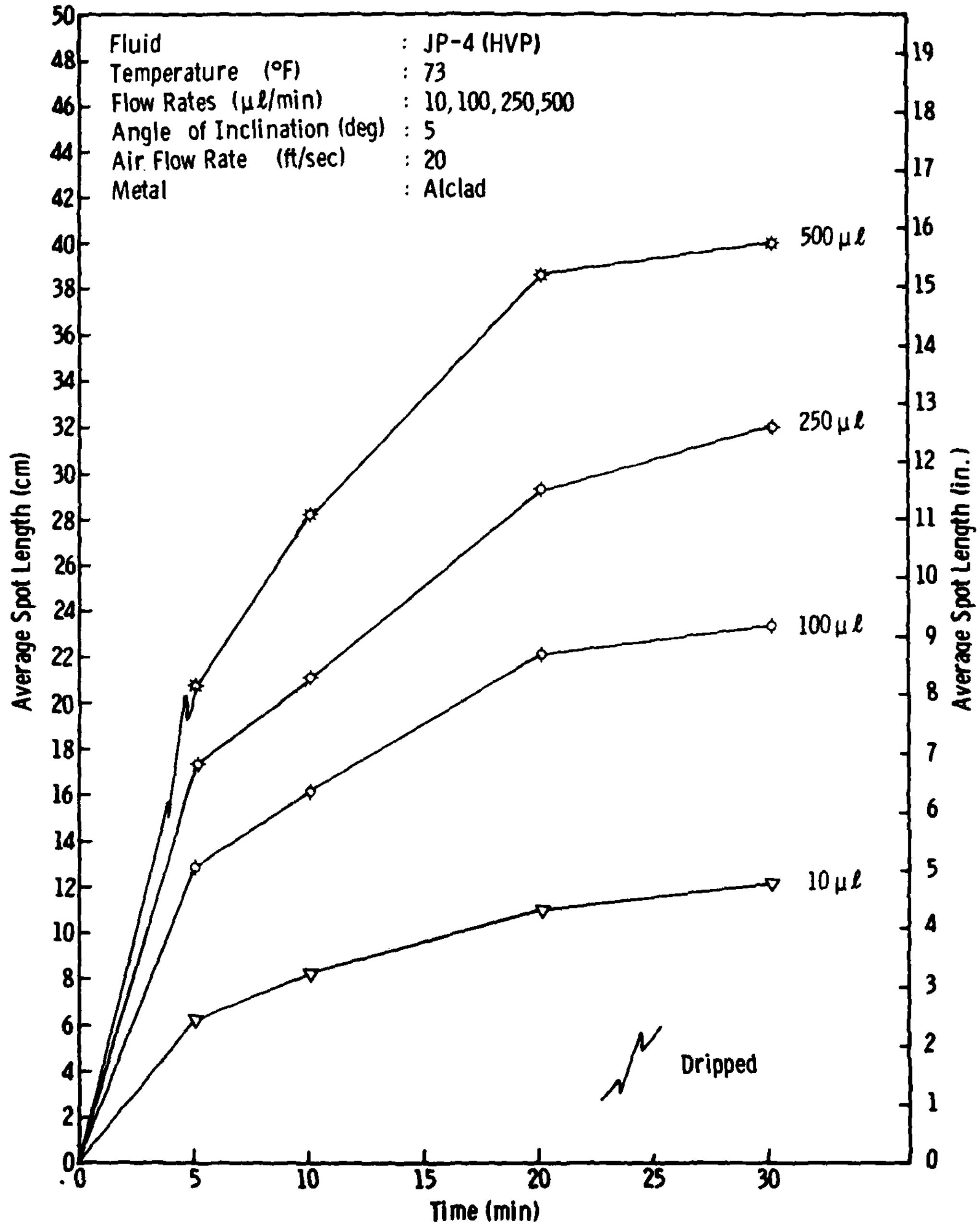
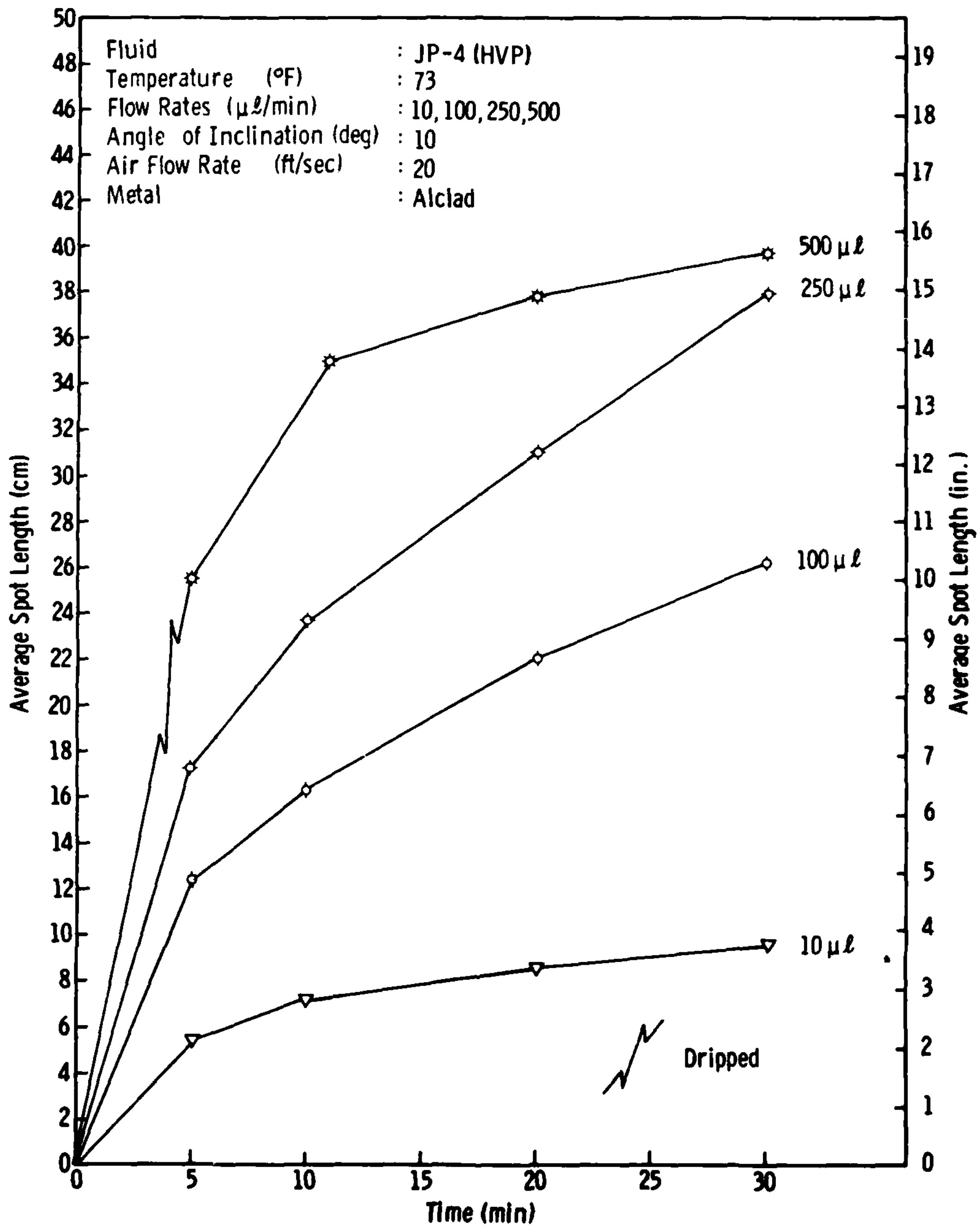
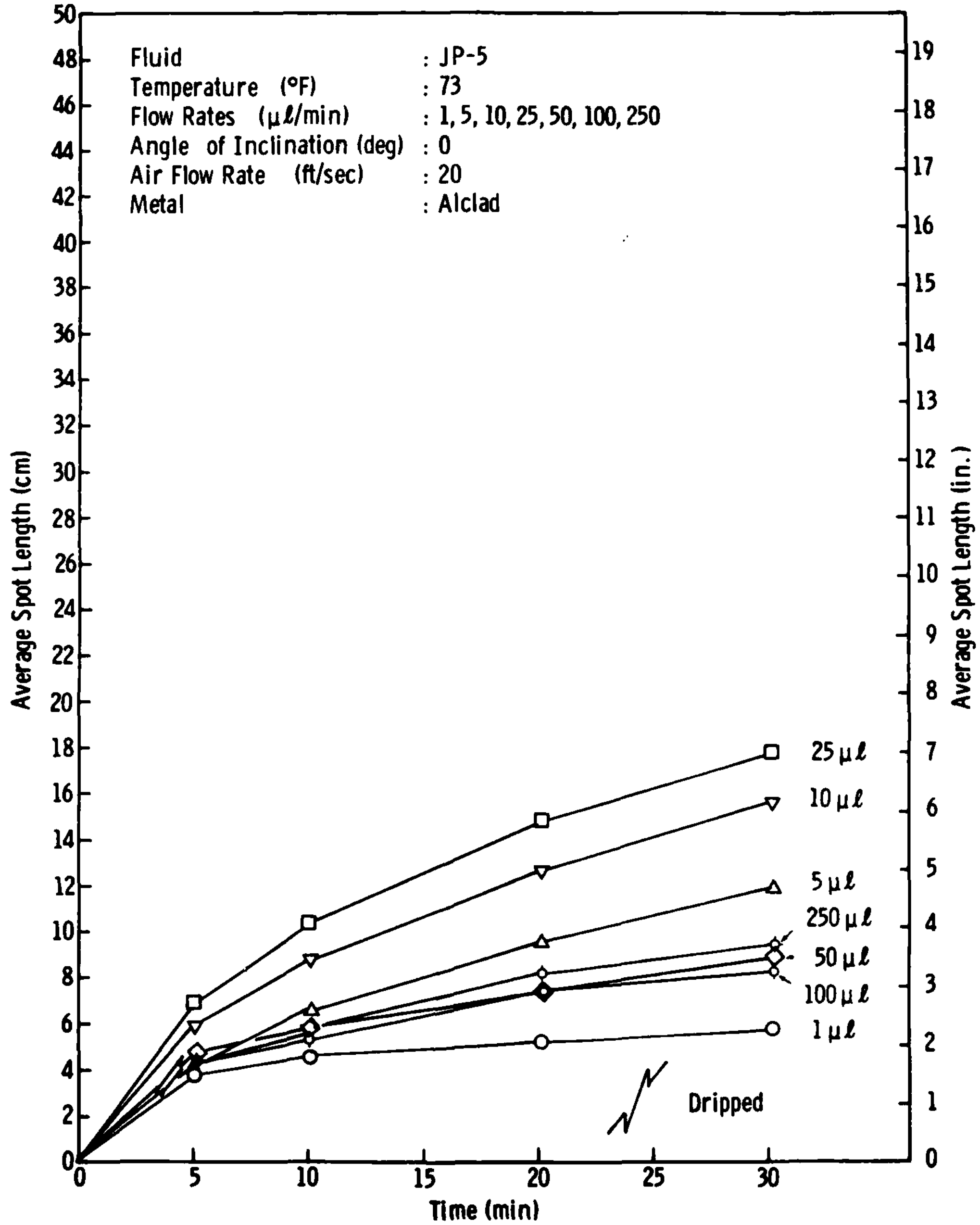

Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rates (µℓ/min) : 10, 100, 250, 500
Angle of Inclination (deg) : 5
Air Flow Rate (ft/sec) : 20
Metal : Alclad
500 µℓ
250 µℓ
100 µℓ
10 µℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 31.



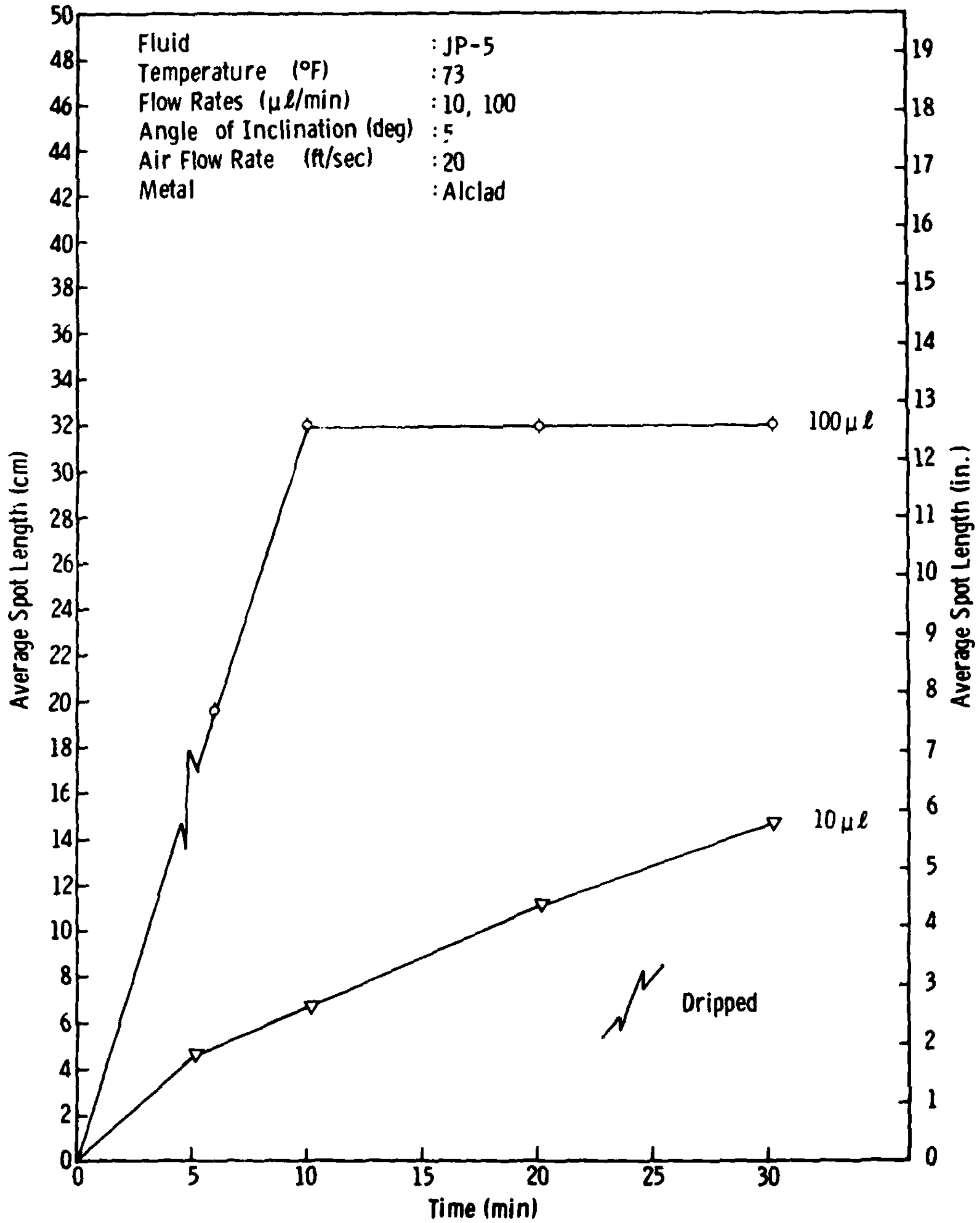
Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 10, 100, 250, 500
Angle of Inclination (deg) : 10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
500 μℓ
250 μℓ
100 μℓ
10 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 32.



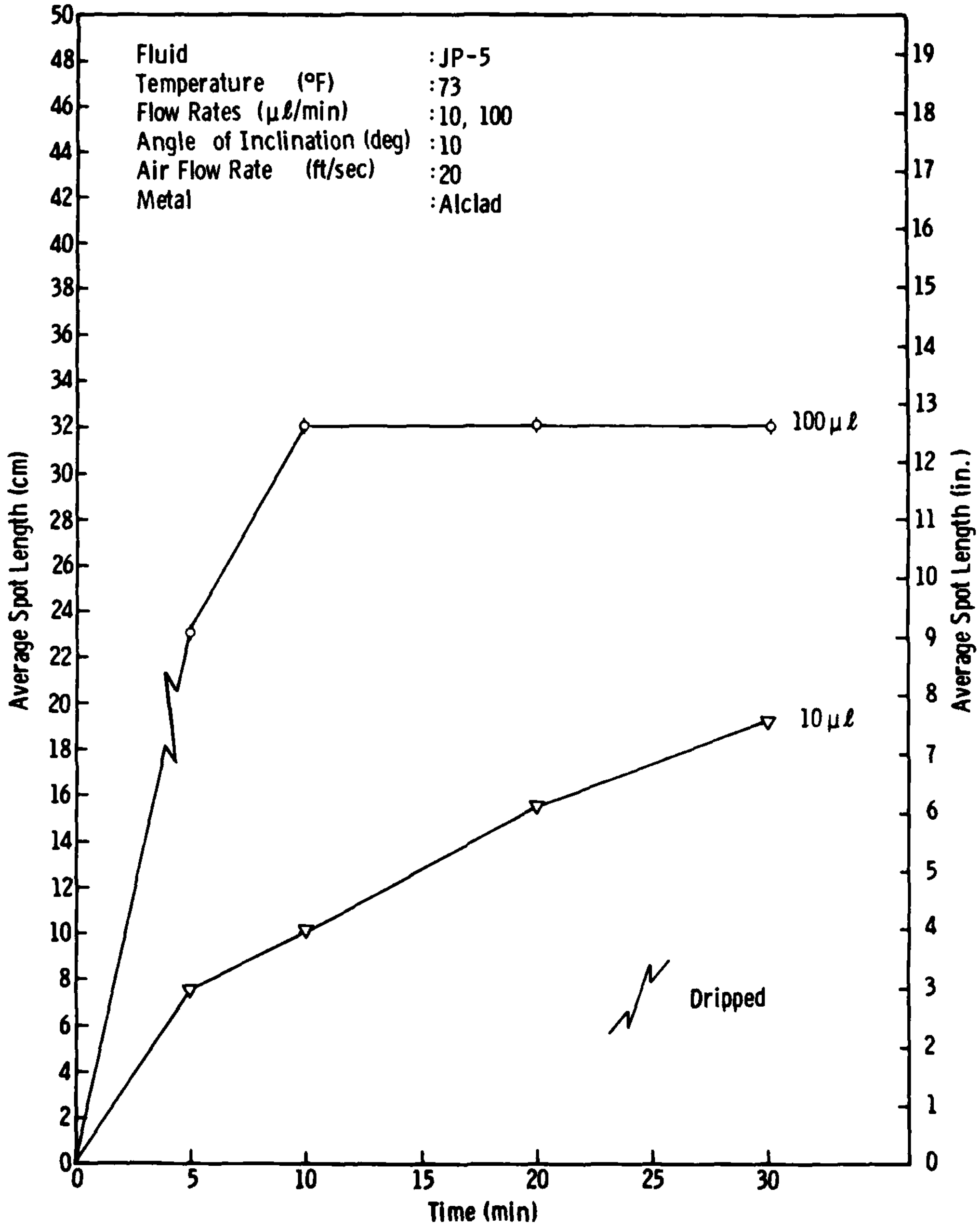
Fluid : JP-5
Temperature (°F) : 73
Flow Rates (μℓ/min) : 1, 5, 10, 25, 50, 100, 250
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
25 μℓ
10 μℓ
5 μℓ
250 μℓ
50 μℓ
100 μℓ
1 μℓ
Dripped


Figure 33.



Fluid : JP-5
Temperature (°F) : 73
Flow Rates (μℓ/min) : 10, 100
Angle of Inclination (deg) : 5
Air Flow Rate (ft/sec) : 20
Metal : Alclad
100 μℓ
10 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 34.



Fluid :JP-5
Temperature (°F) :73
Flow Rates (μℓ/min) :10, 100
Angle of Inclination (deg) :10
Air Flow Rate (ft/sec) :20
Metal :Alclad
100 μℓ
10 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 35.

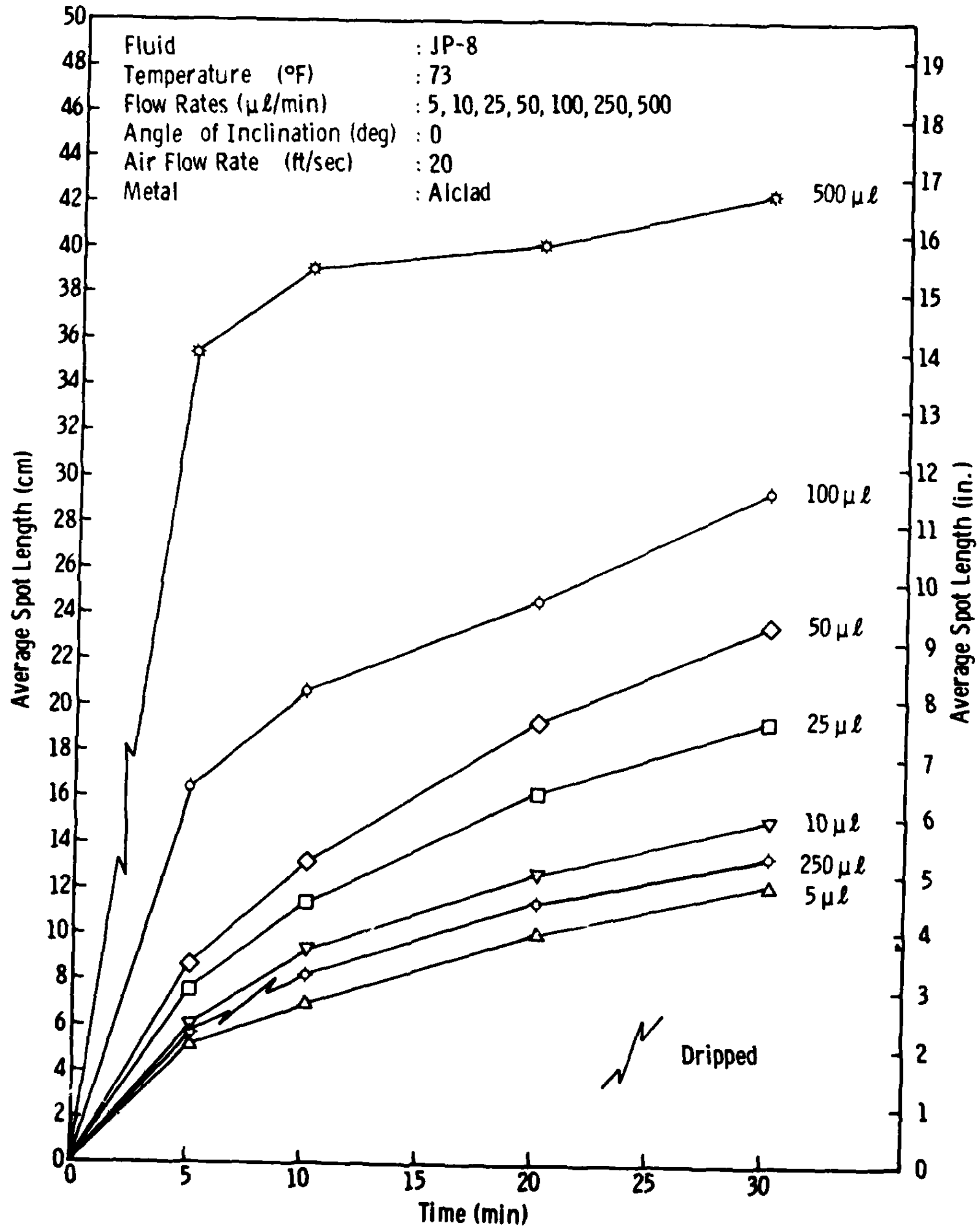
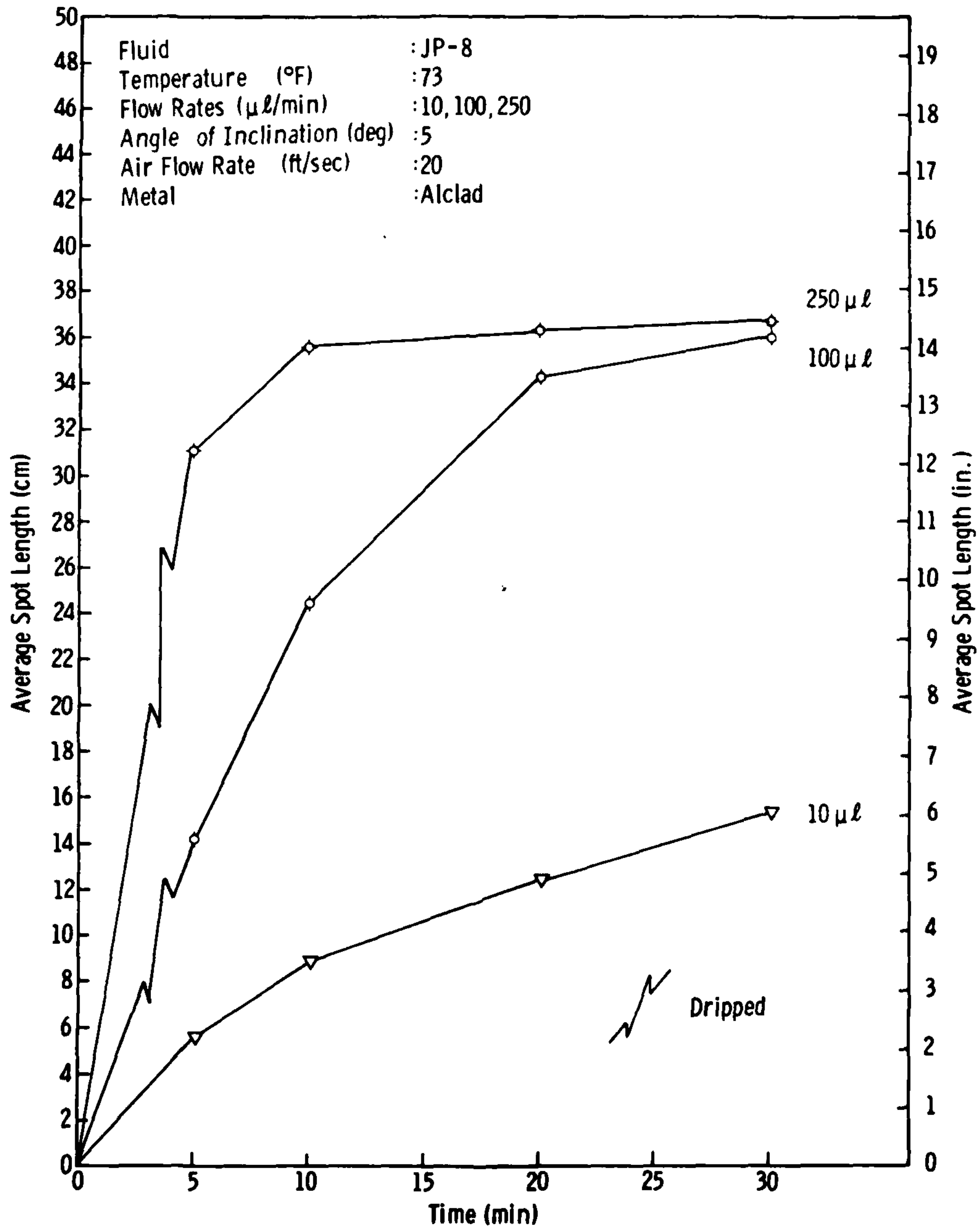
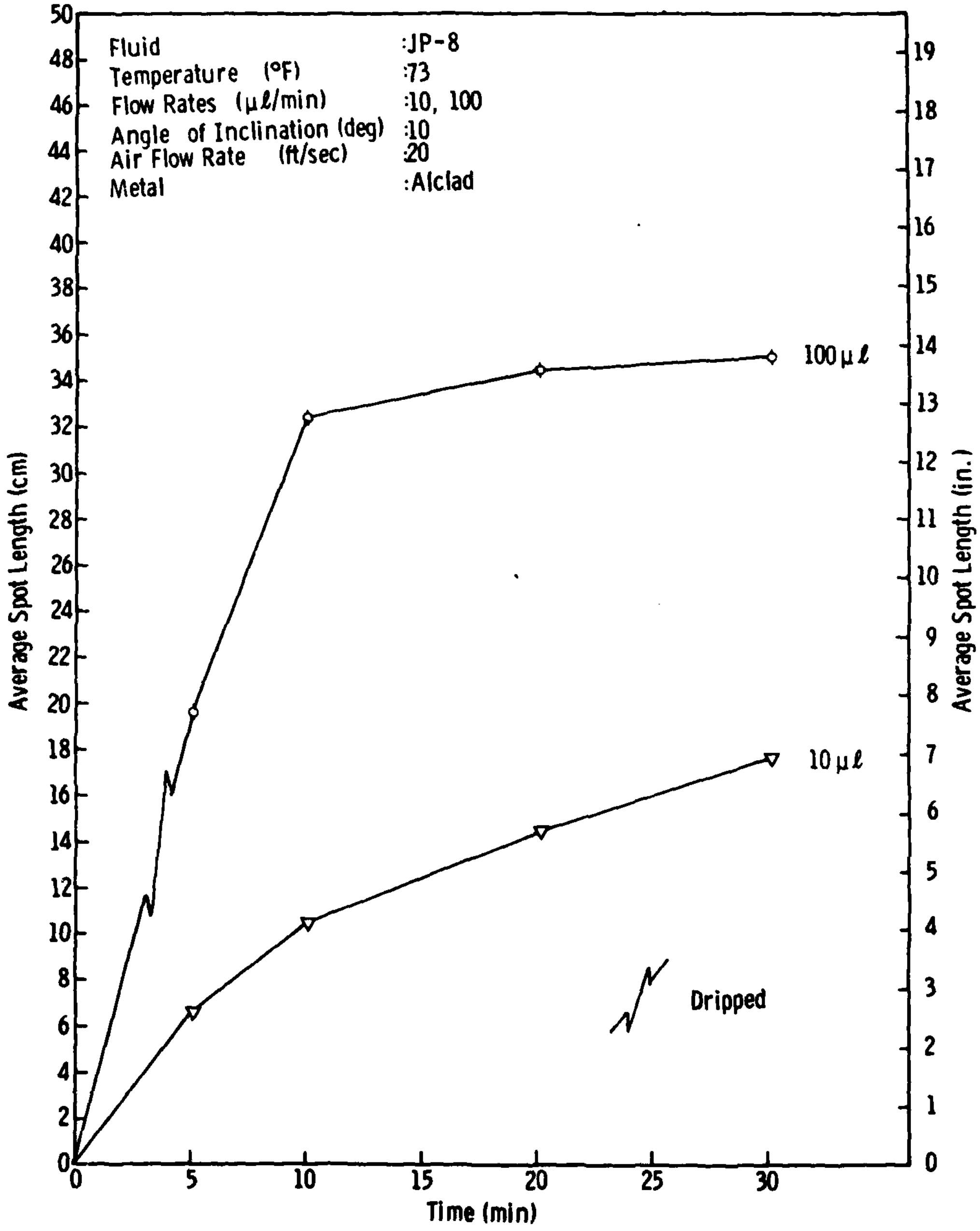

Fluid : JP-8
Temperature (°F) : 73
Flow Rates (μℓ/min) : 5, 10, 25, 50, 100, 250, 500
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
500 μℓ
100 μℓ
50 μℓ
25 μℓ
10 μℓ
250 μℓ
5 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30

Figure 36.



Fluid :JP-8
Temperature (°F) :73
Flow Rates (µℓ/min) :10, 100, 250
Angle of Inclination (deg) :5
Air Flow Rate (ft/sec) :20
Metal :Alclad
250 µℓ
100 µℓ
10 µℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 37.



Fluid :JP-8
Temperature (°F) :73
Flow Rates (μℓ/min) :10, 100
Angle of Inclination (deg) :10
Air Flow Rate (ft/sec) :20
Metal :Alclad
100 μℓ
10 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 38.

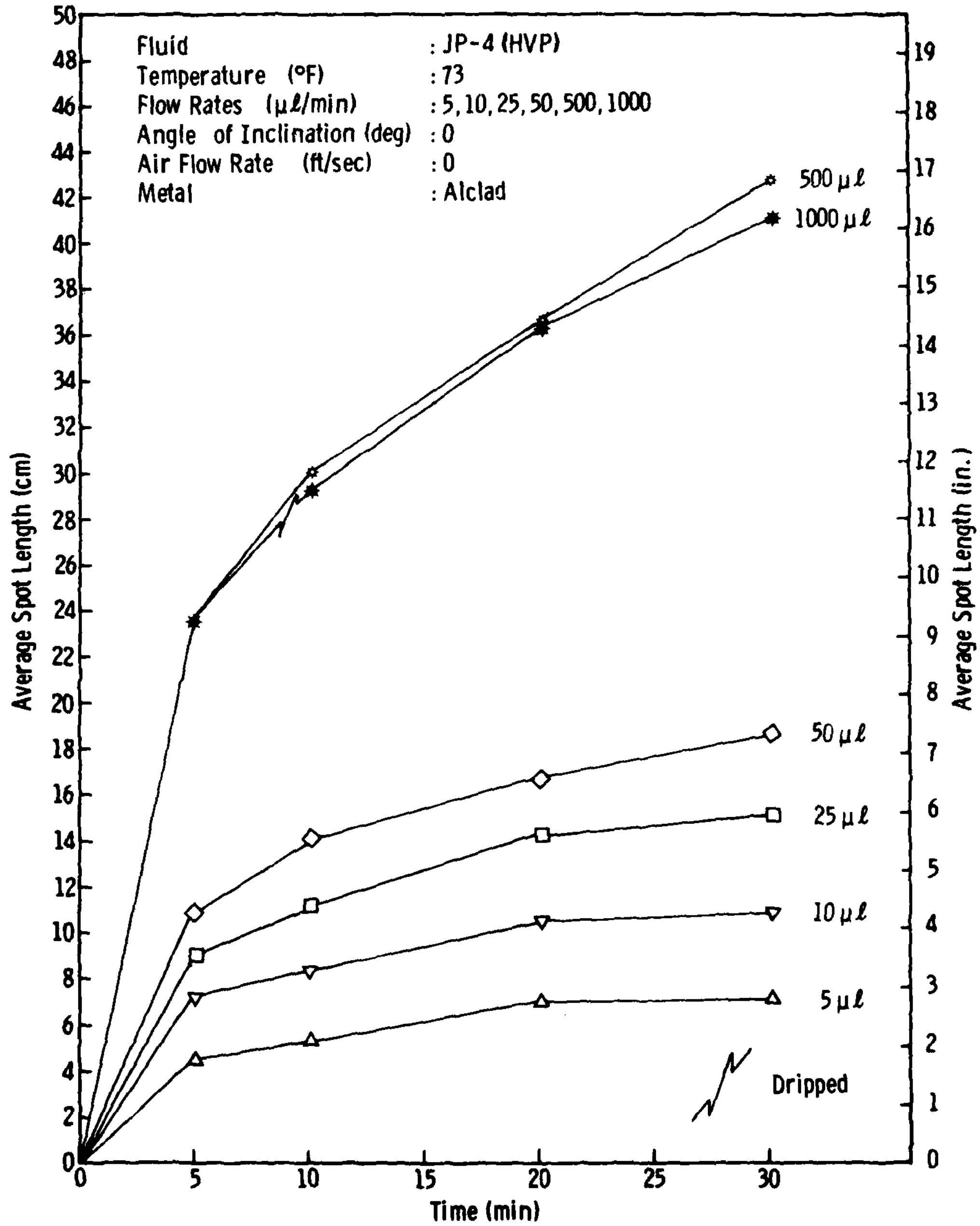
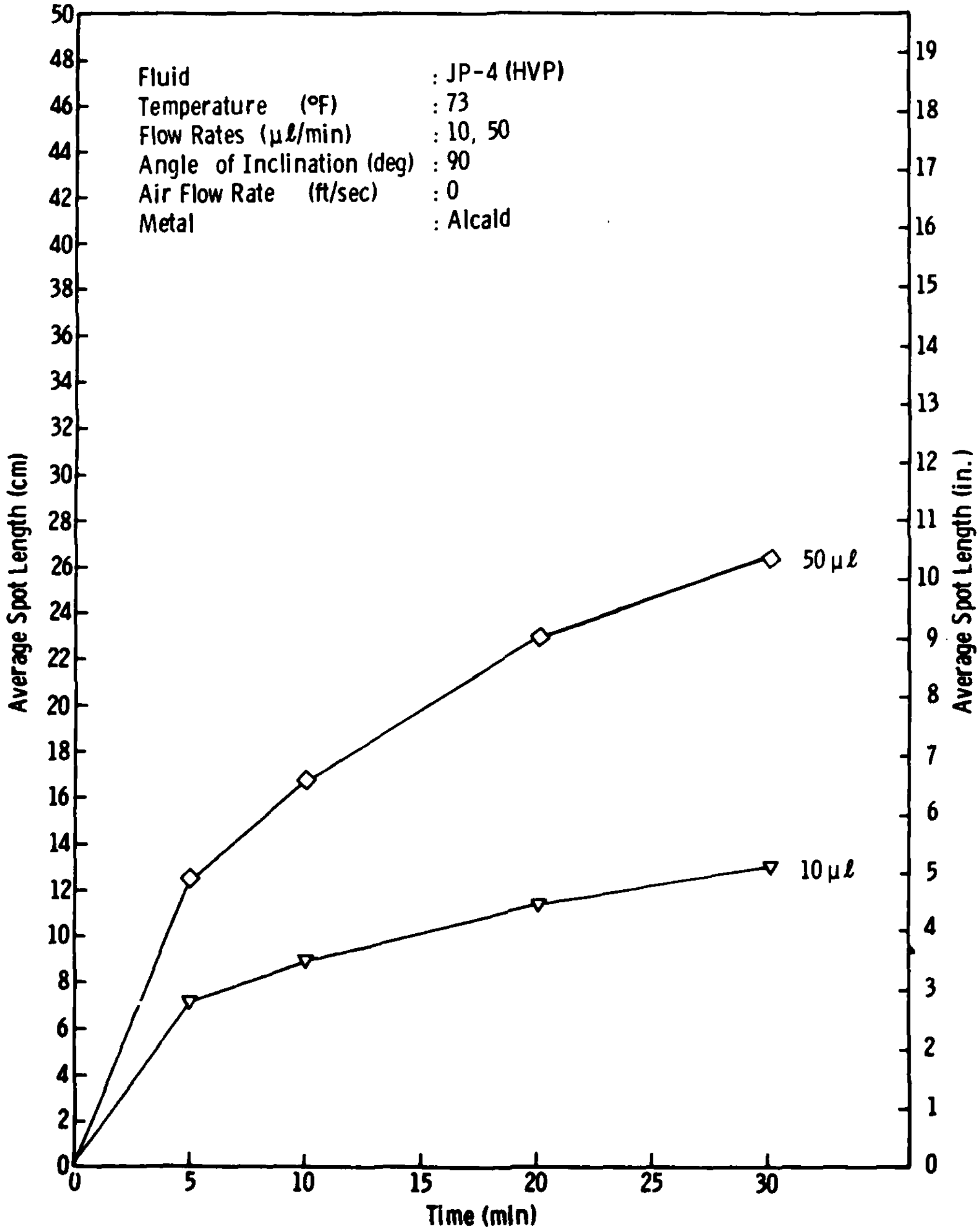
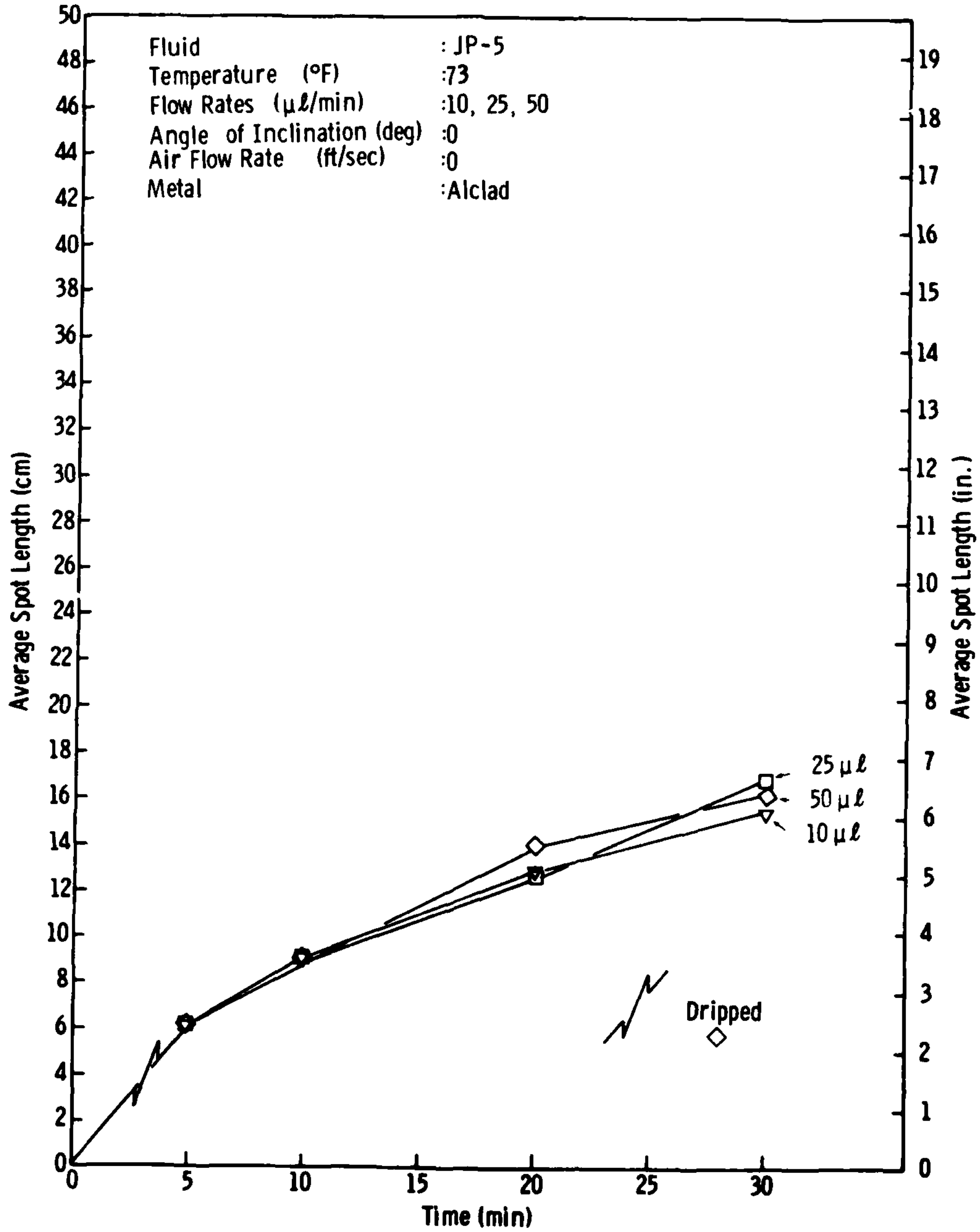

Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 5, 10, 25, 50, 500, 1000
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
500 μℓ
1000 μℓ
50 μℓ
25 μℓ
10 μℓ
5 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 39.



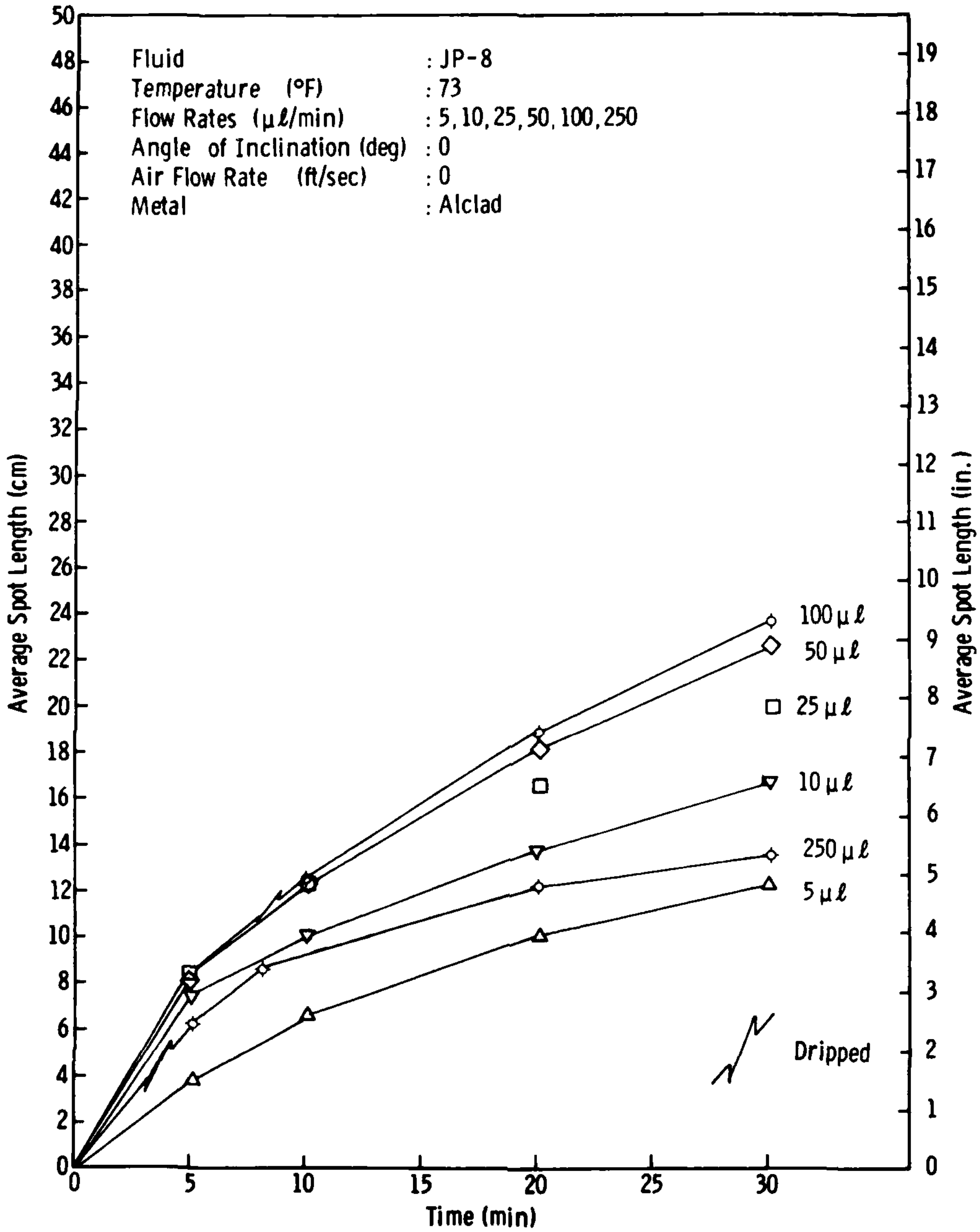
Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 10, 50
Angle of Inclination (deg) : 90
Air Flow Rate (ft/sec) : 0
Metal : Alcald
50 μℓ
10 μℓ
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 40.



Fluid : JP-5
Temperature (°F) :73
Flow Rates (μℓ/min) :10, 25, 50
Angle of Inclination (deg) :0
Air Flow Rate (ft/sec) :0
Metal :Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
25 μℓ
50 μℓ
10 μℓ
Dripped
0
5
10
15
20
25
30


Figure 41.



Fluid : JP-8
Temperature (°F) : 73
Flow Rates (μℓ/min) : 5, 10, 25, 50, 100, 250
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
100 μℓ
50 μℓ
25 μℓ
10 μℓ
250 μℓ
5 μℓ
Dripped
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19


Figure 42.

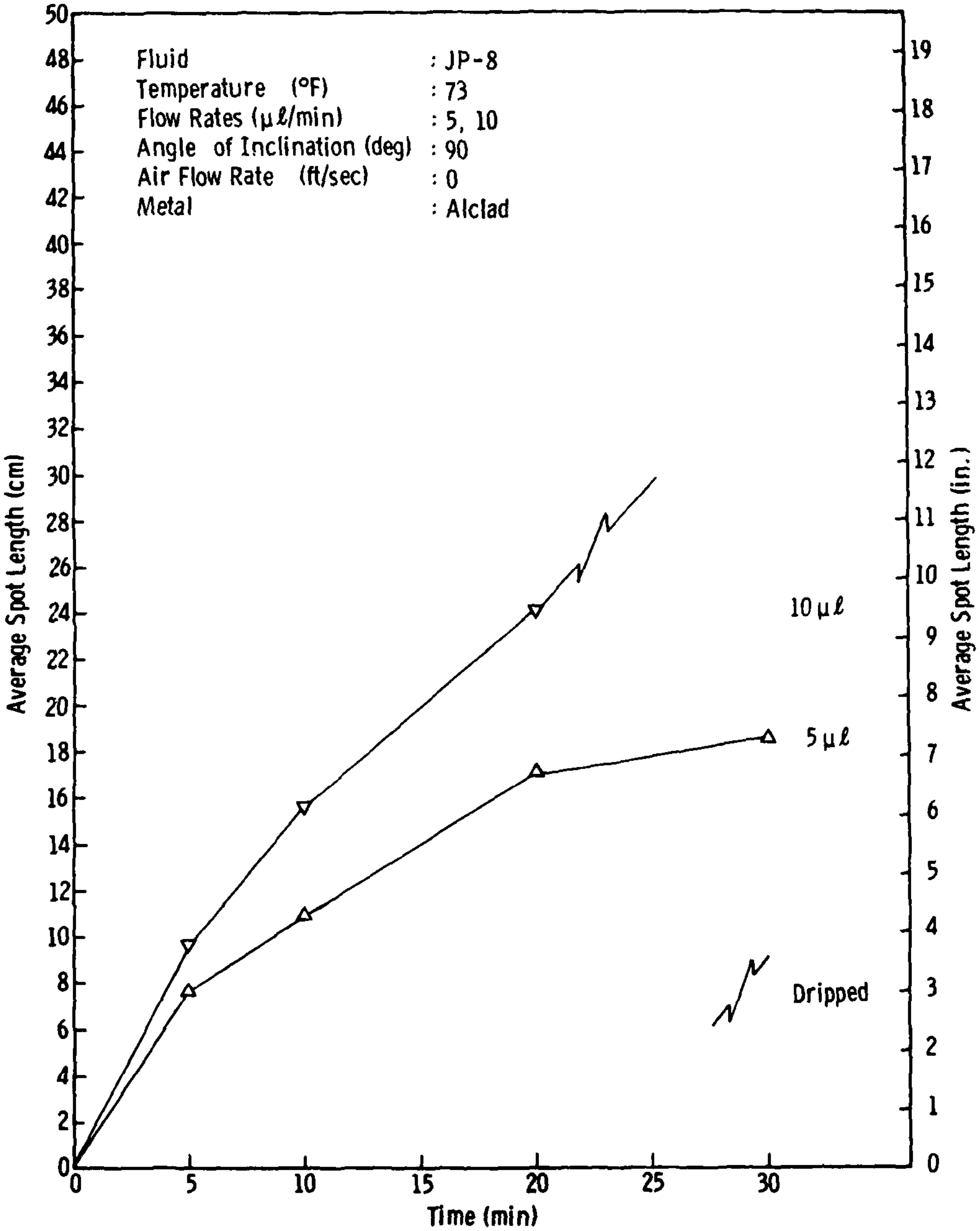

Fluid : JP-8
Temperature (°F) : 73
Flow Rates (μℓ/min) : 5, 10
Angle of Inclination (deg) : 90
Air Flow Rate (ft/sec) : 0
Metal : Alclad
10 μℓ
5 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 43.

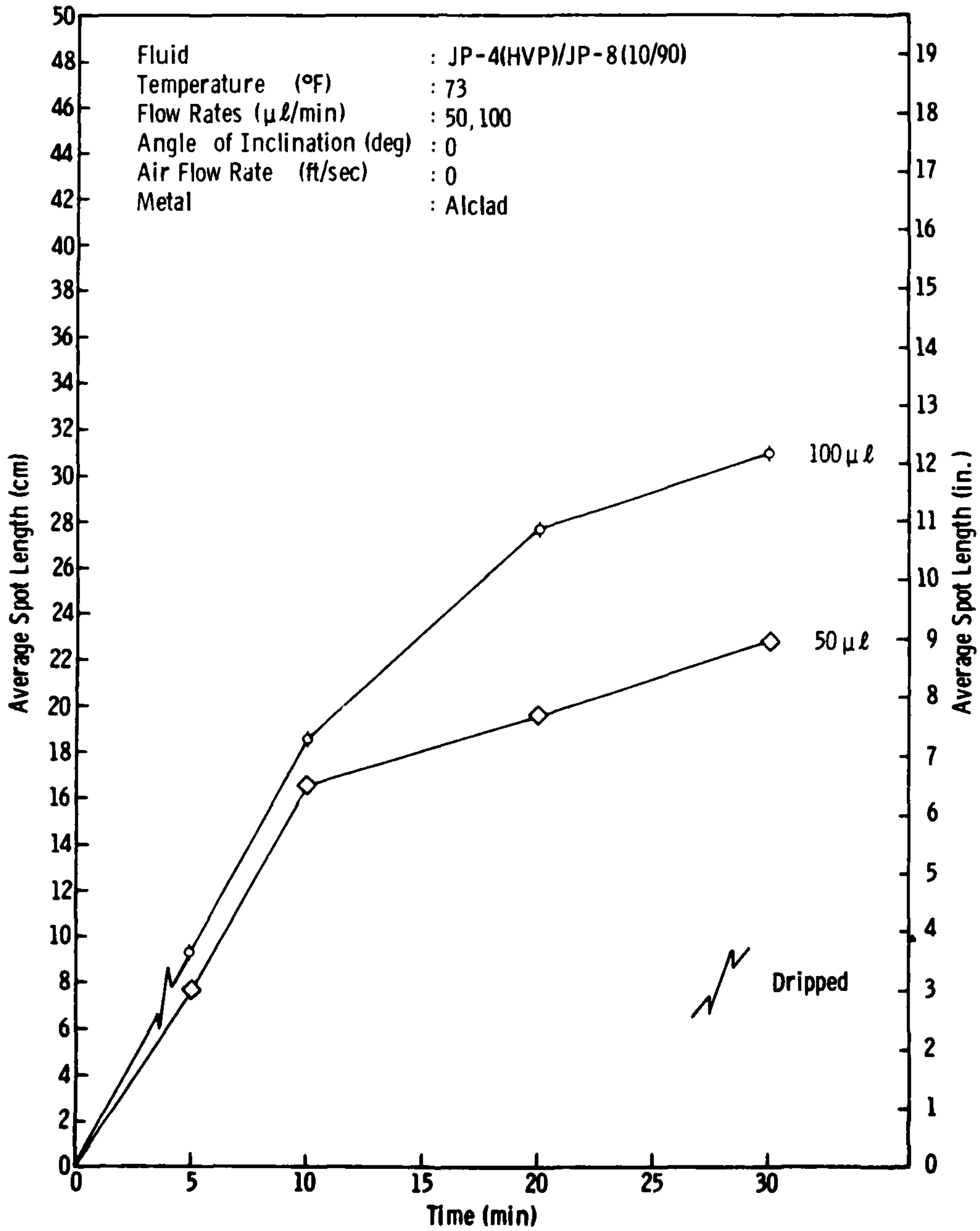

Fluid : JP-4(HVP)/JP-8(10/90)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 50, 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
100 μℓ
50 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 44.

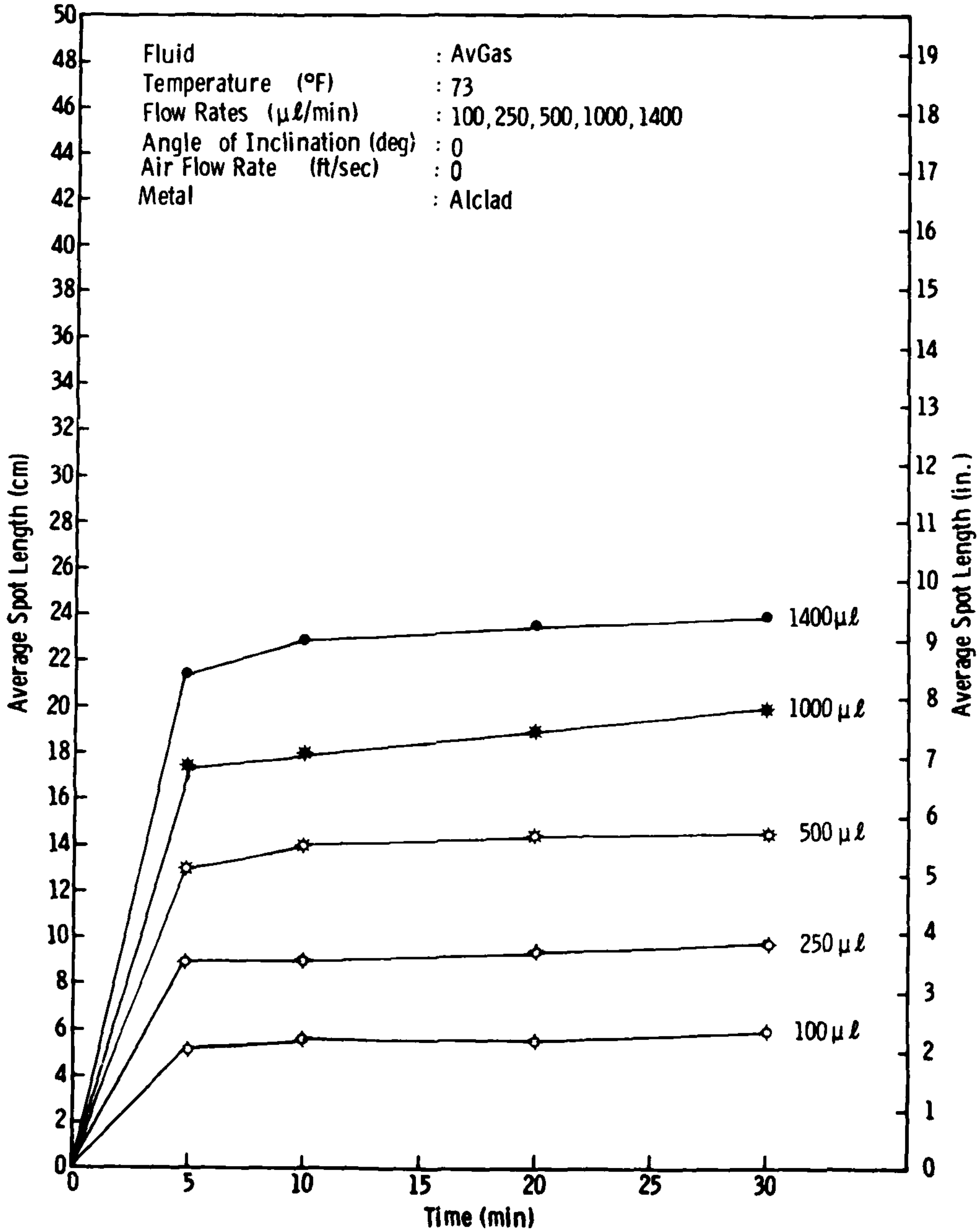
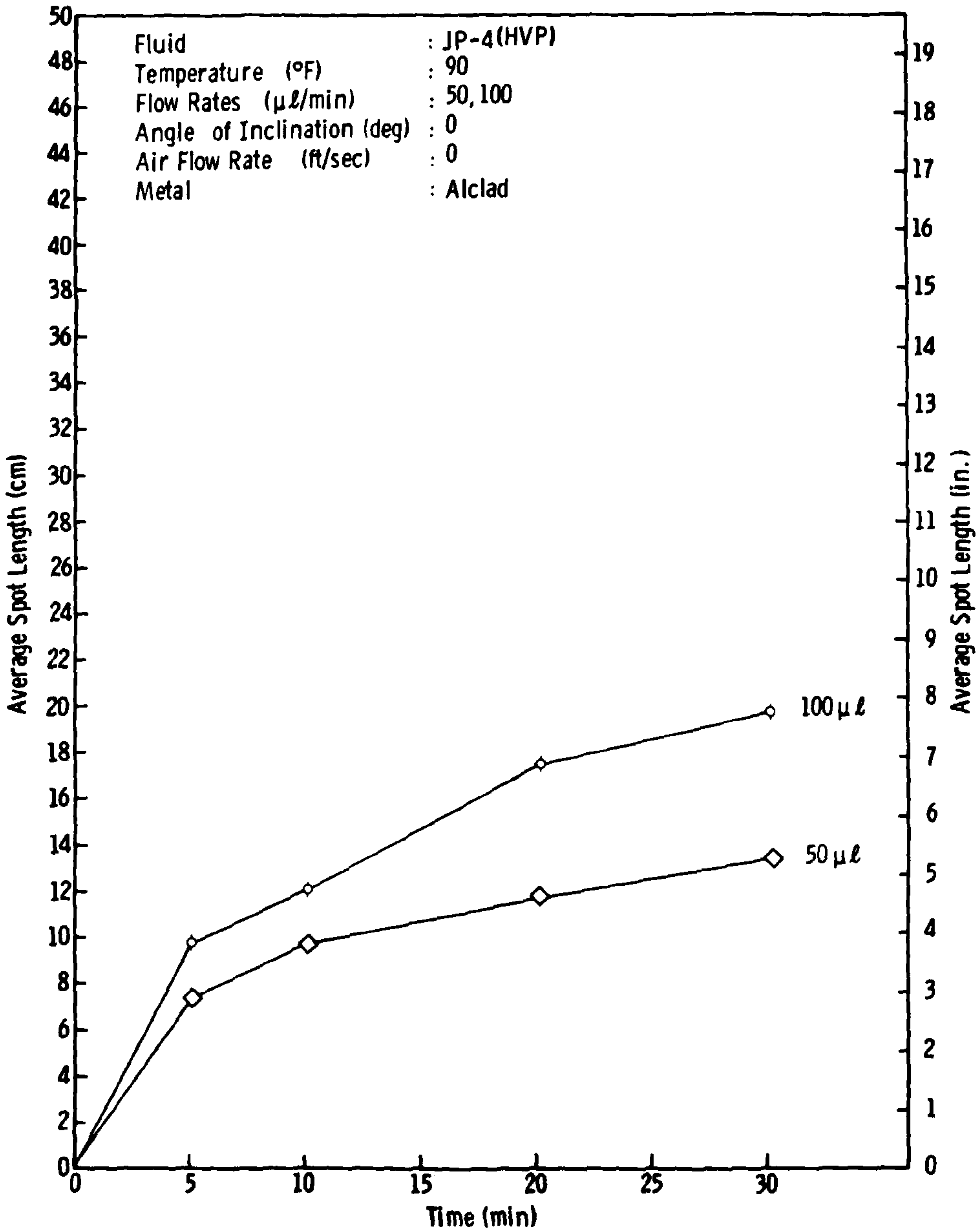
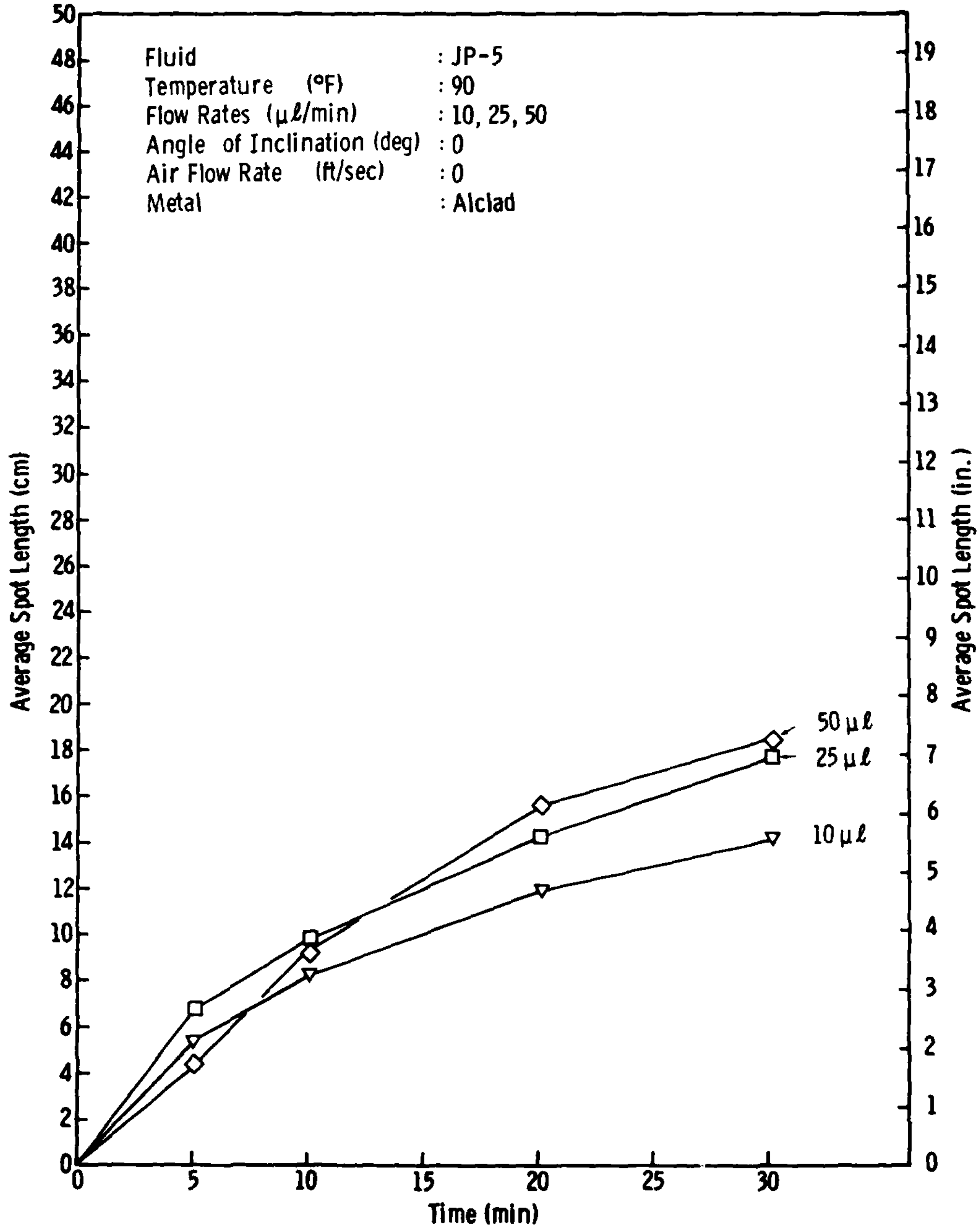

Fluid : AvGas
Temperature (°F) : 73
Flow Rates (μℓ/min) : 100, 250, 500, 1000, 1400
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
1400μℓ
1000 μℓ
500 μℓ
250 μℓ
100 μℓ

Figure 45.



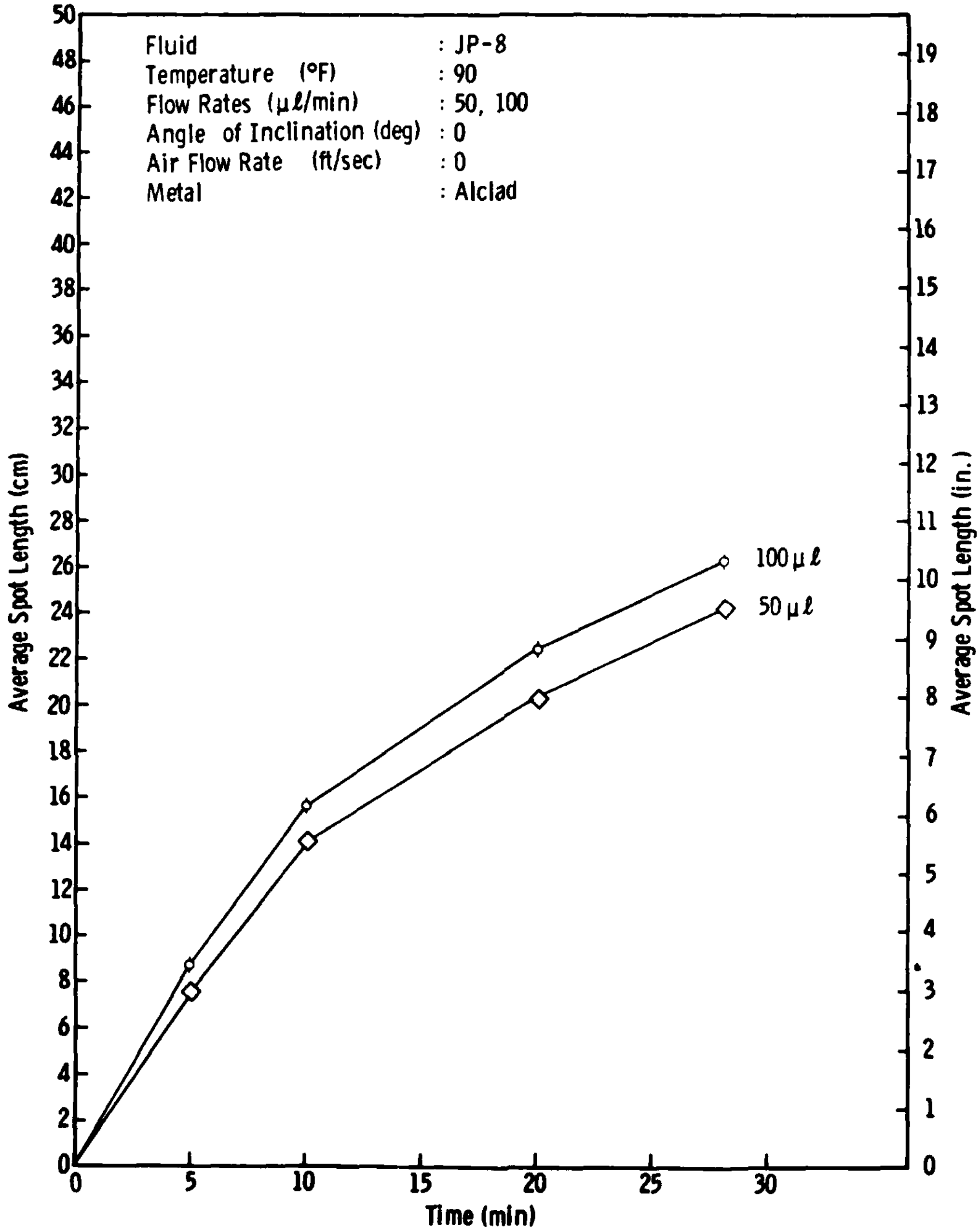
Fluid : JP-4(HVP)
Temperature (°F) : 90
Flow Rates (μℓ/min) : 50, 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
100 μℓ
50 μℓ
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
5
10
15
20
25
30


Figure 46.



Fluid : JP-5
Temperature (°F) : 90
Flow Rates (μℓ/min) : 10, 25, 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
50 μℓ
25 μℓ
10 μℓ
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 47.



Fluid : JP-8
Temperature (°F) : 90
Flow Rates (μℓ/min) : 50, 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
100 μℓ
50 μℓ
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 48.

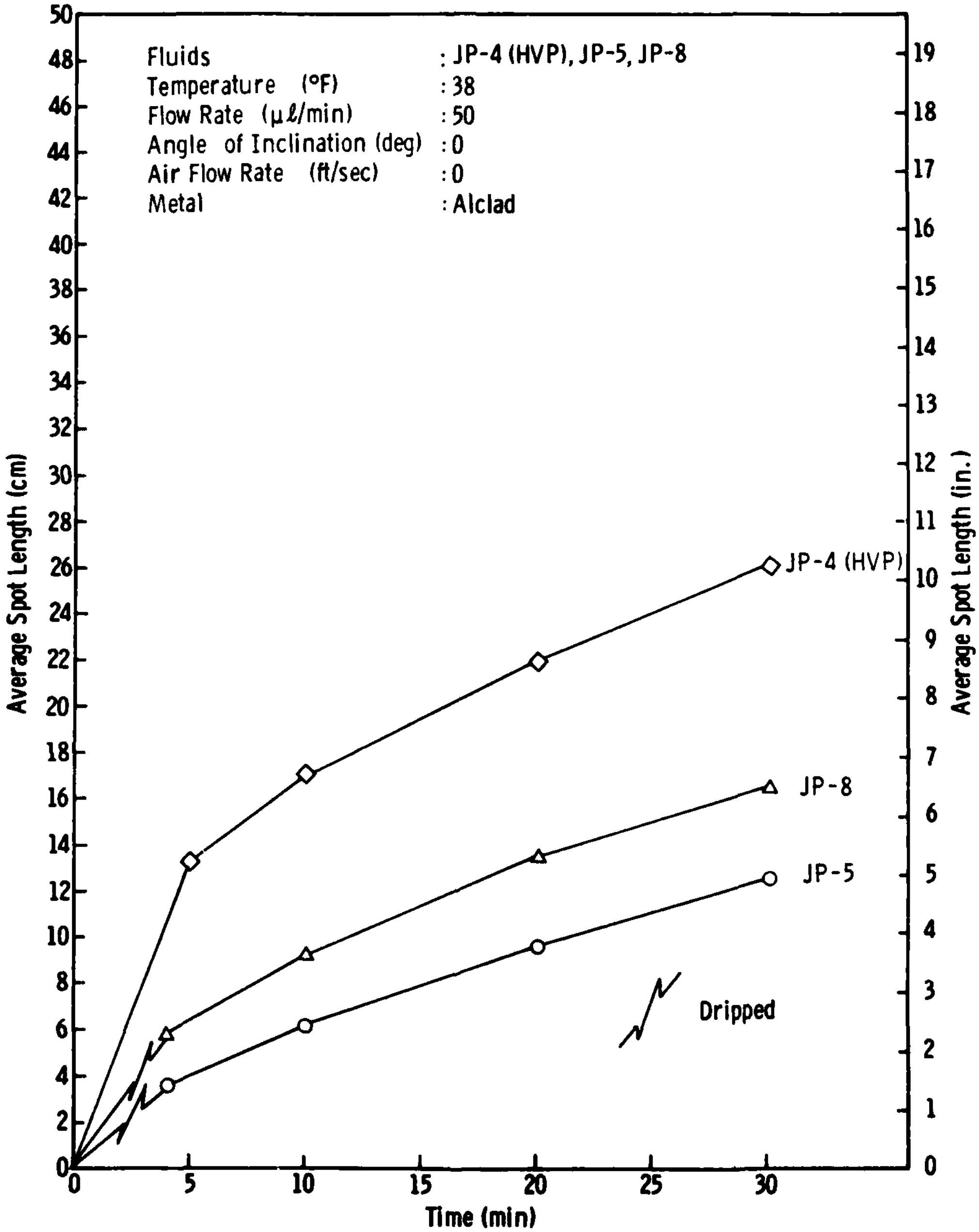

Fluids : JP-4 (HVP), JP-5, JP-8
Temperature (°F) : 38
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
JP-4 (HVP)
JP-8
JP-5
Dripped
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 49.

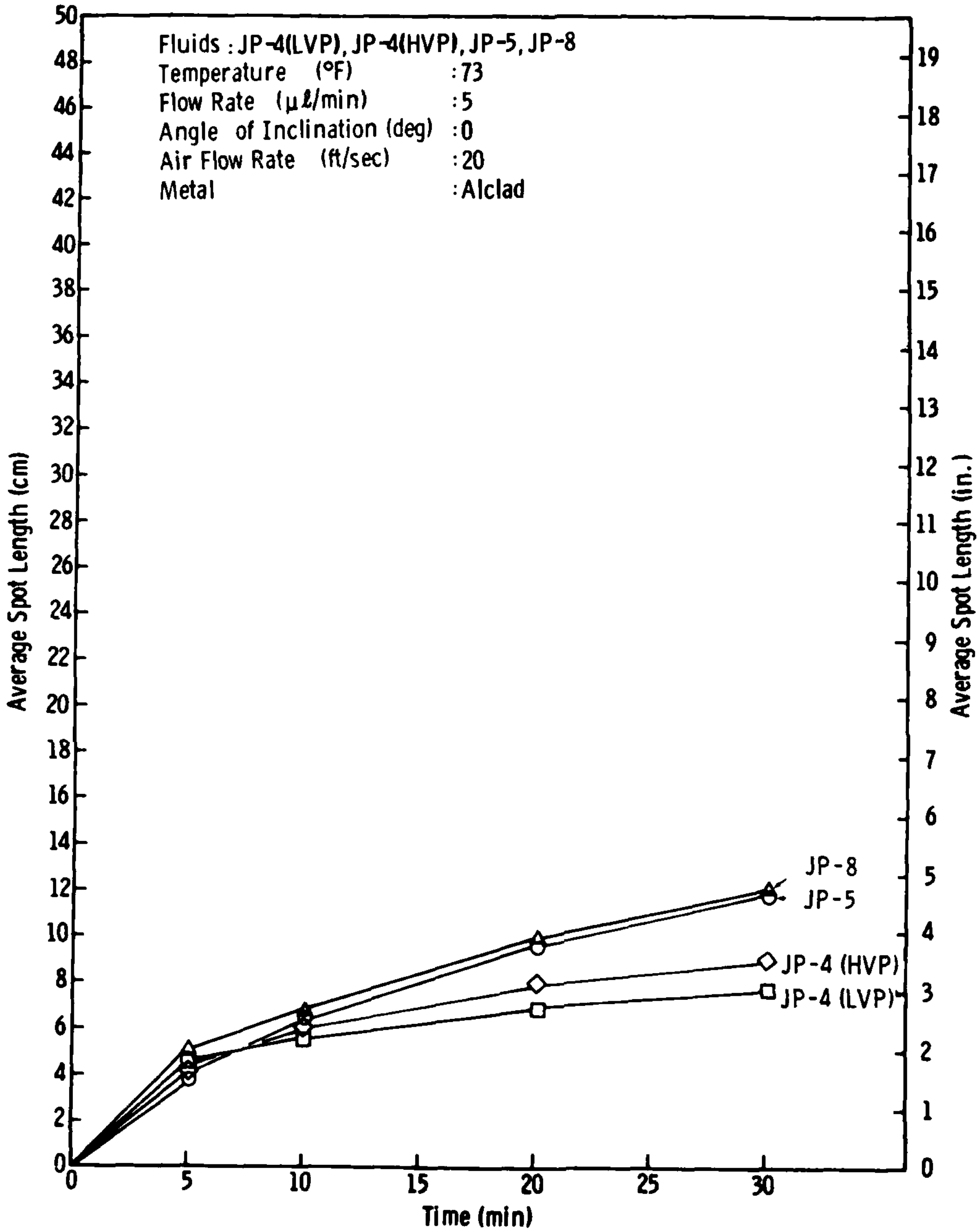
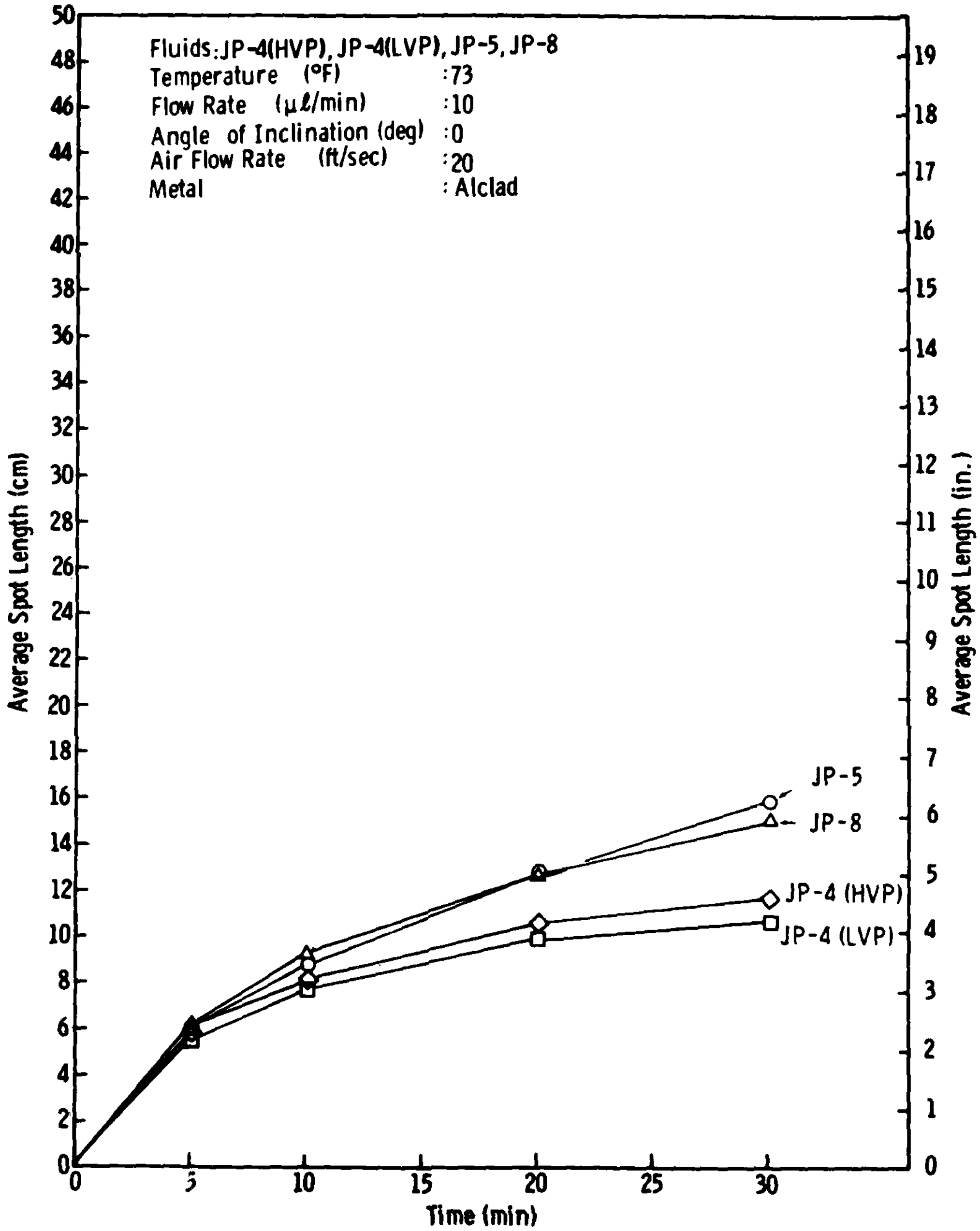

Fluids : JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 5
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
JP-8
JP-5
JP-4 (HVP)
JP-4 (LVP)

Figure 50.



Fluids:JP-4(HVP), JP-4(LVP), JP-5, JP-8
Temperature (°F) :73
Flow Rate (μℓ/min) :10
Angle of Inclination (deg) :0
Air Flow Rate (ft/sec) :20
Metal : Alclad
JP-5
JP-8
JP-4 (HVP)
JP-4 (LVP)
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 51.

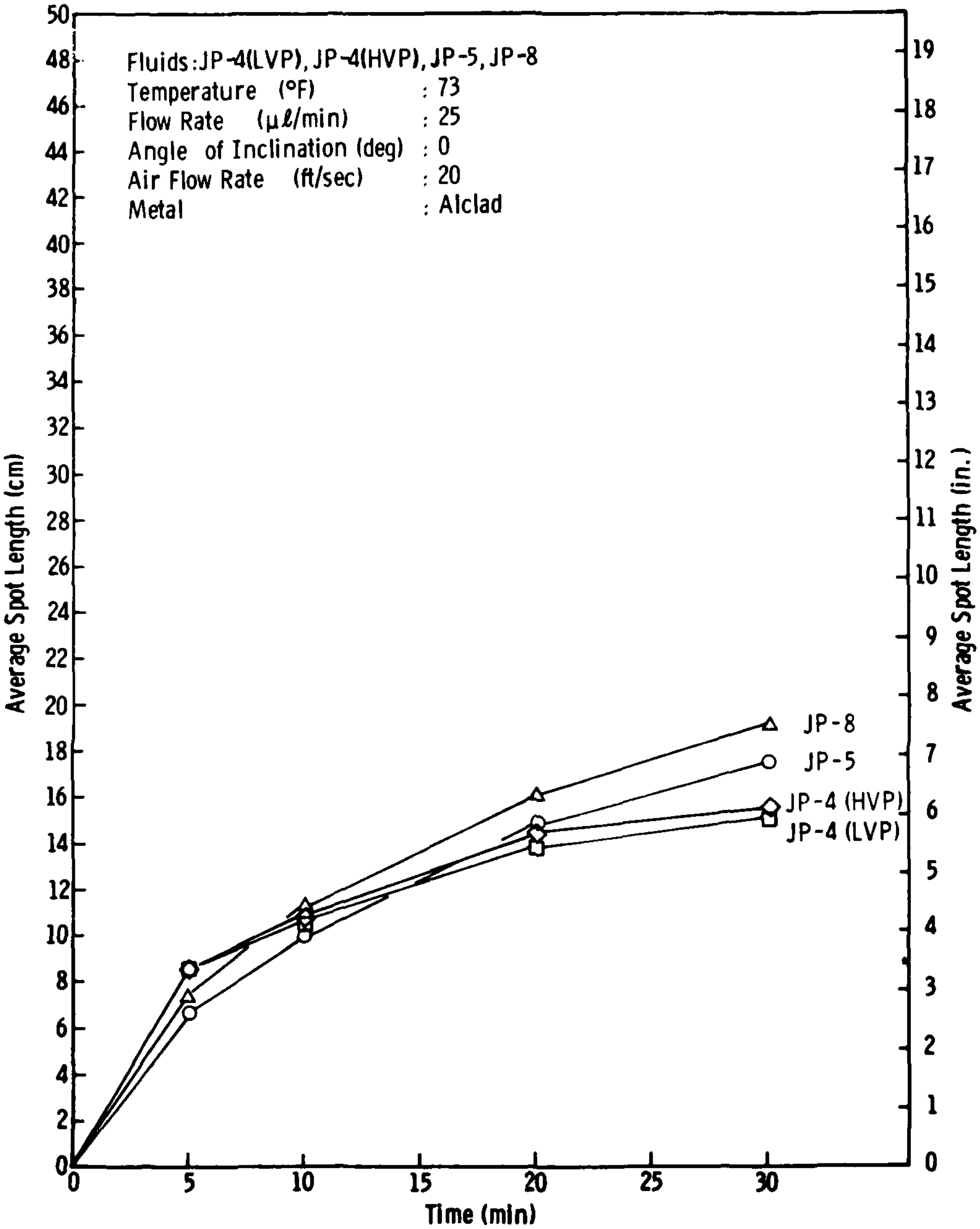

Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 25
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
JP-8
JP-5
JP-4 (HVP)
JP-4 (LVP)
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 52.

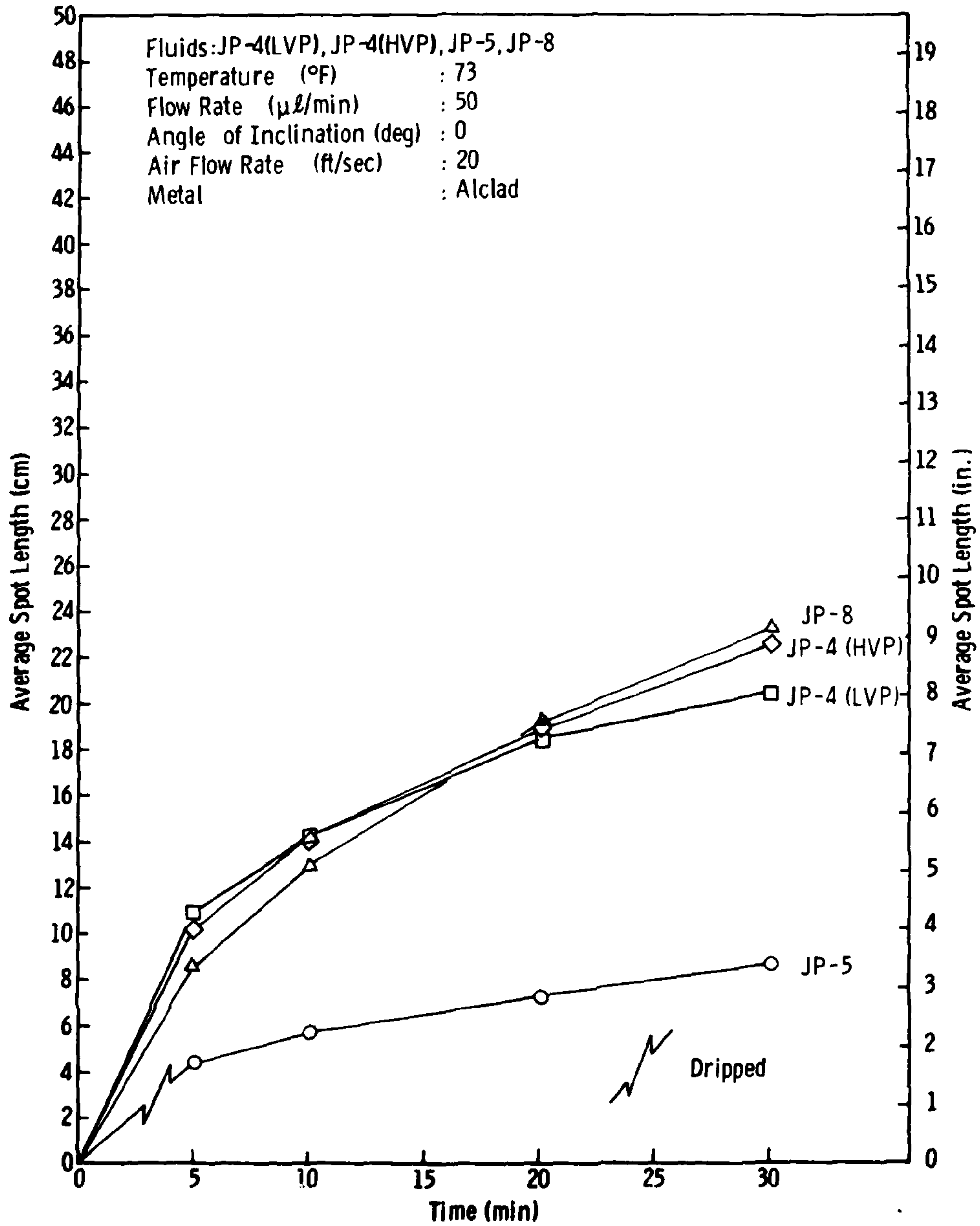

Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
JP-8
JP-4 (HVP)
JP-4 (LVP)
JP-5
Dripped
0
5
10
15
20
25
30
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 53.

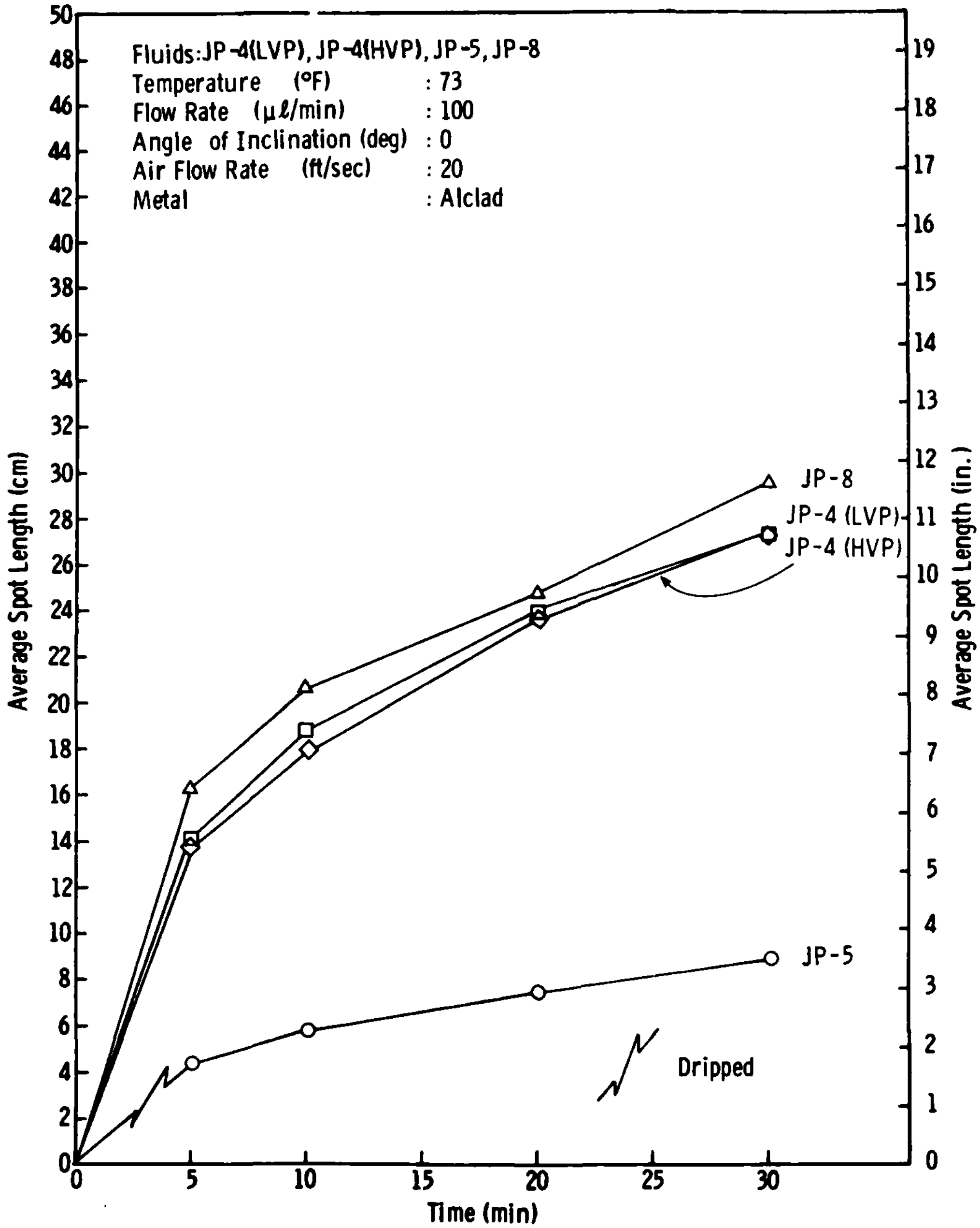
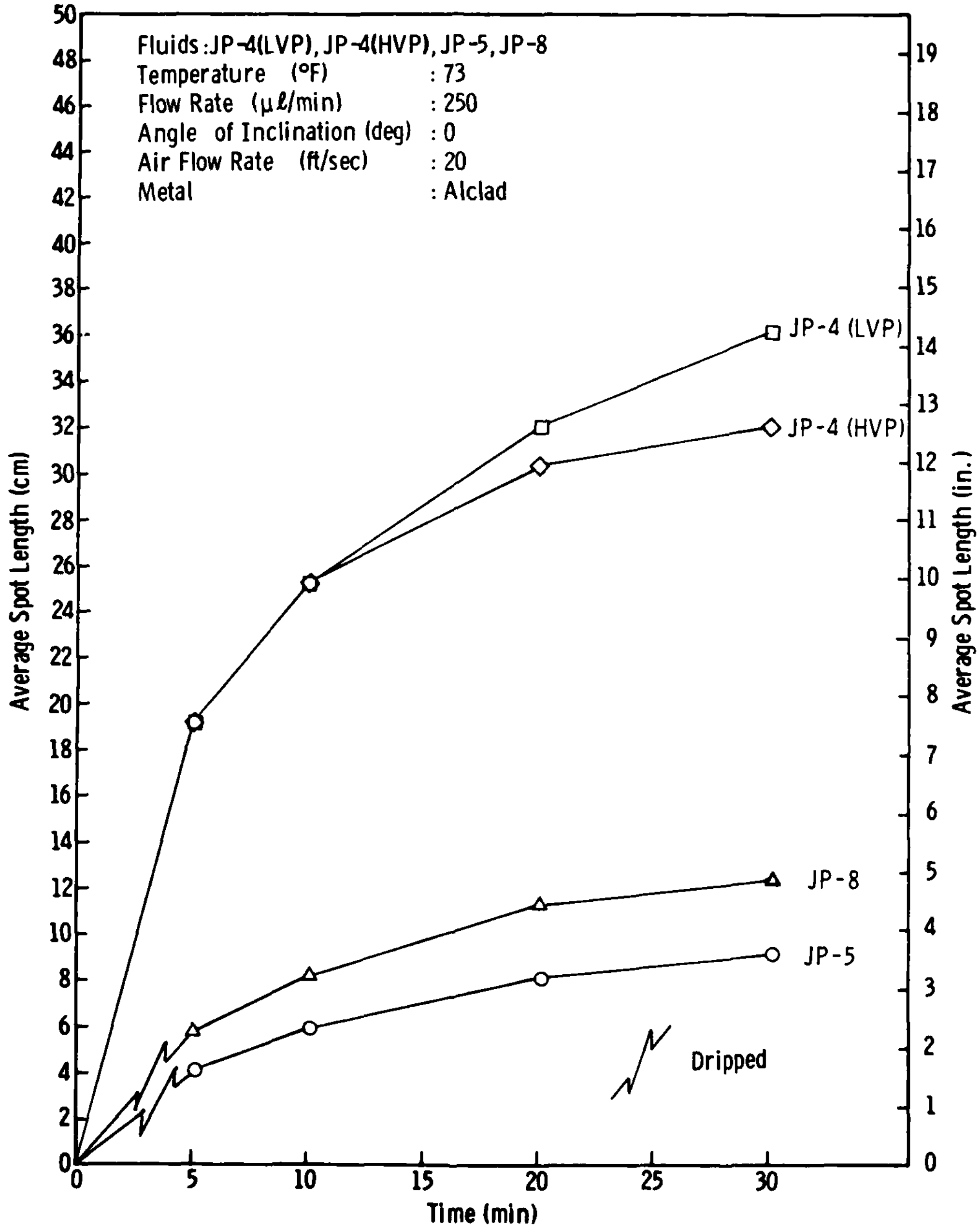

Fluids:JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
JP-8
JP-4 (LVP)
JP-4 (HVP)
JP-5
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 54.



Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 250
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
JP-4 (LVP)
JP-4 (HVP)
JP-8
JP-5
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 55.

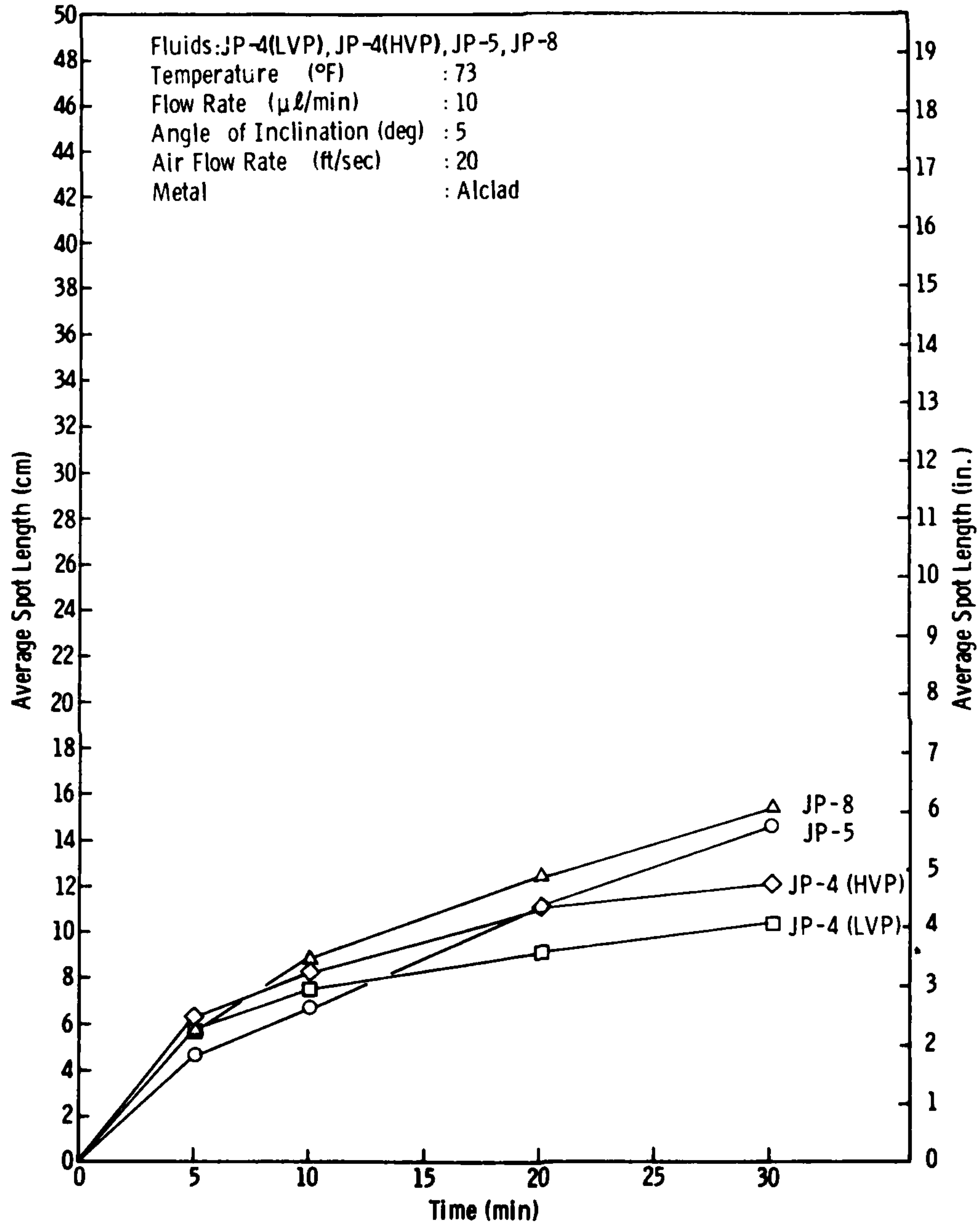
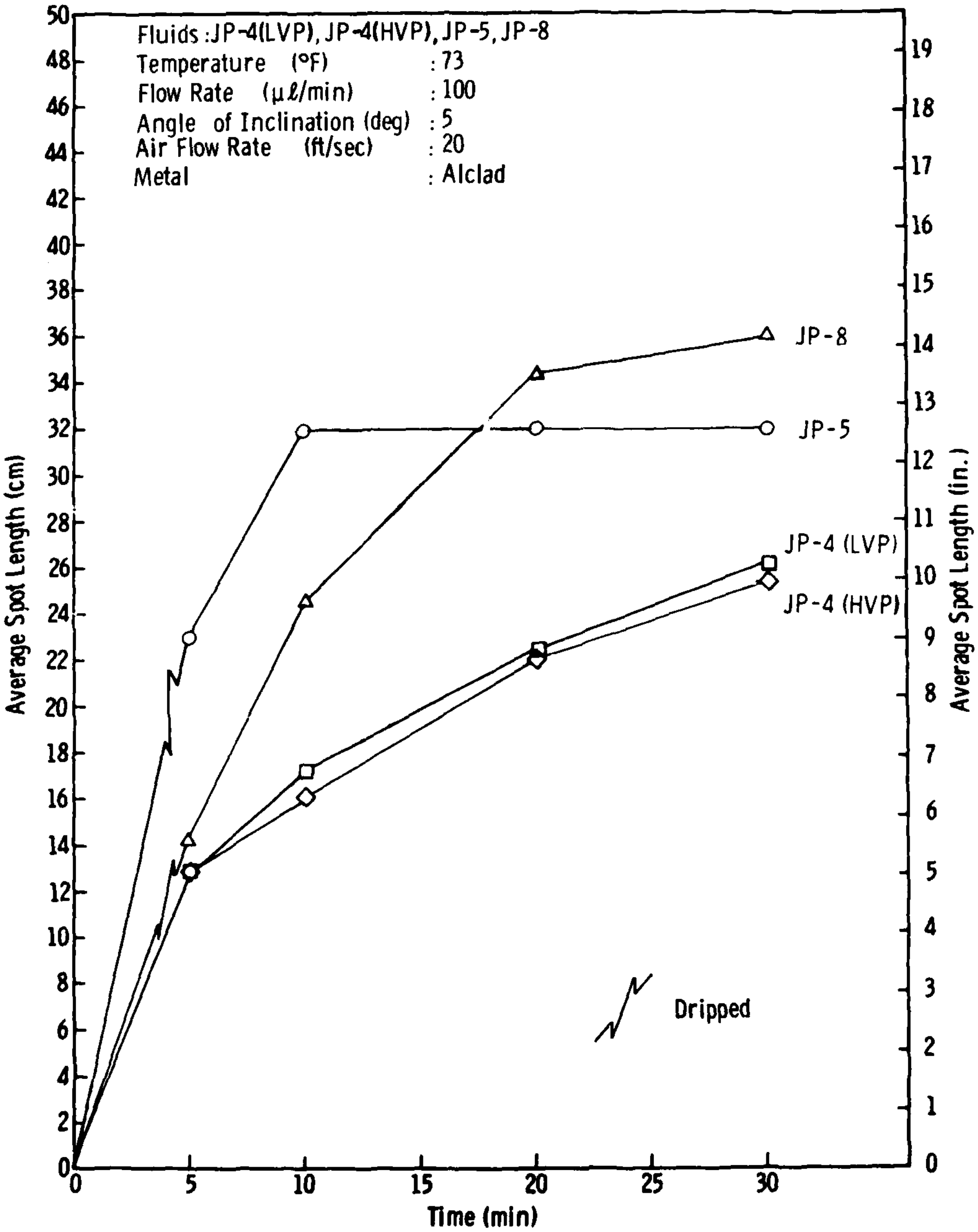
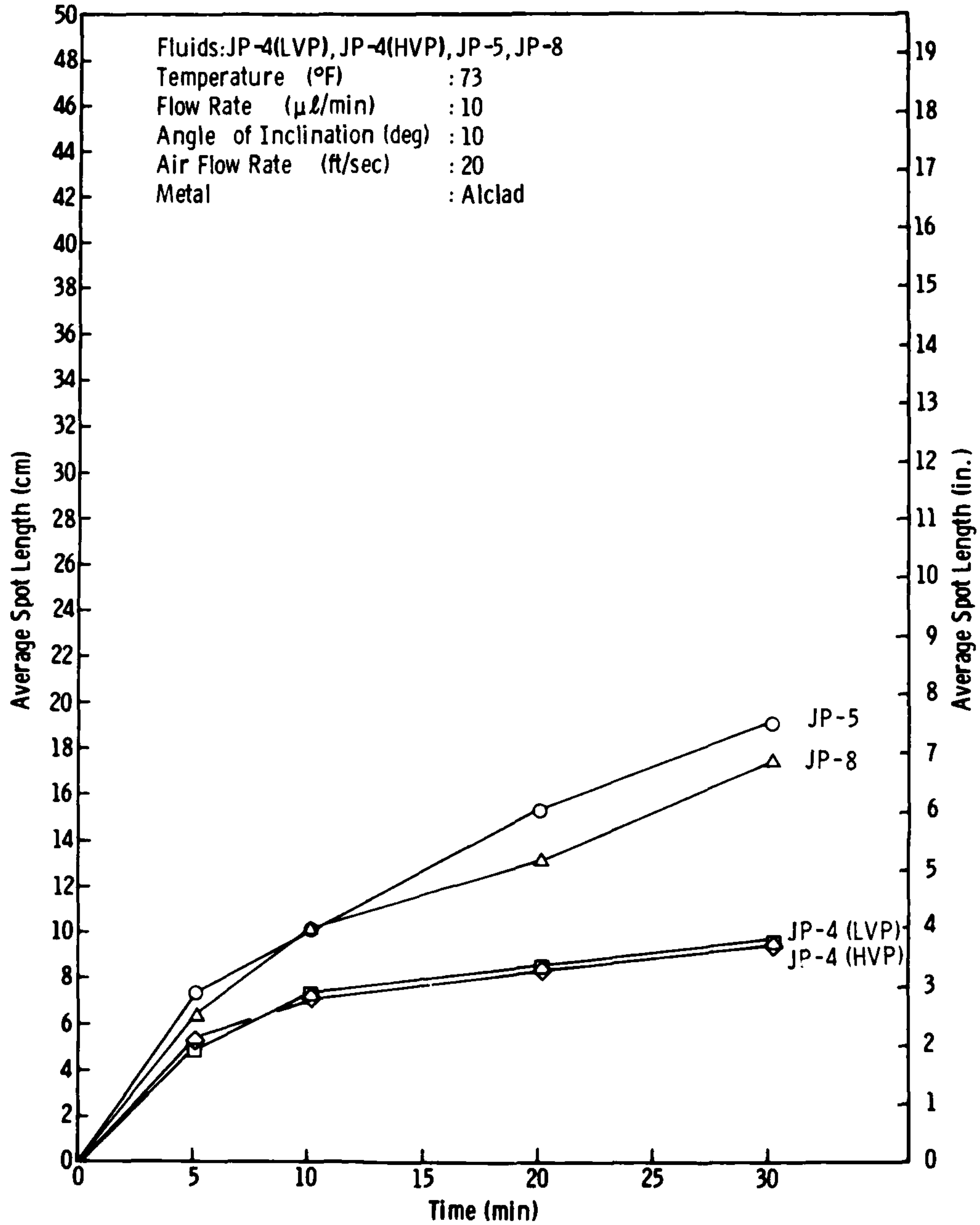

Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angle of Inclination (deg) : 5
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
JP-8
JP-5
JP-4 (HVP)
JP-4 (LVP)

Figure 56.



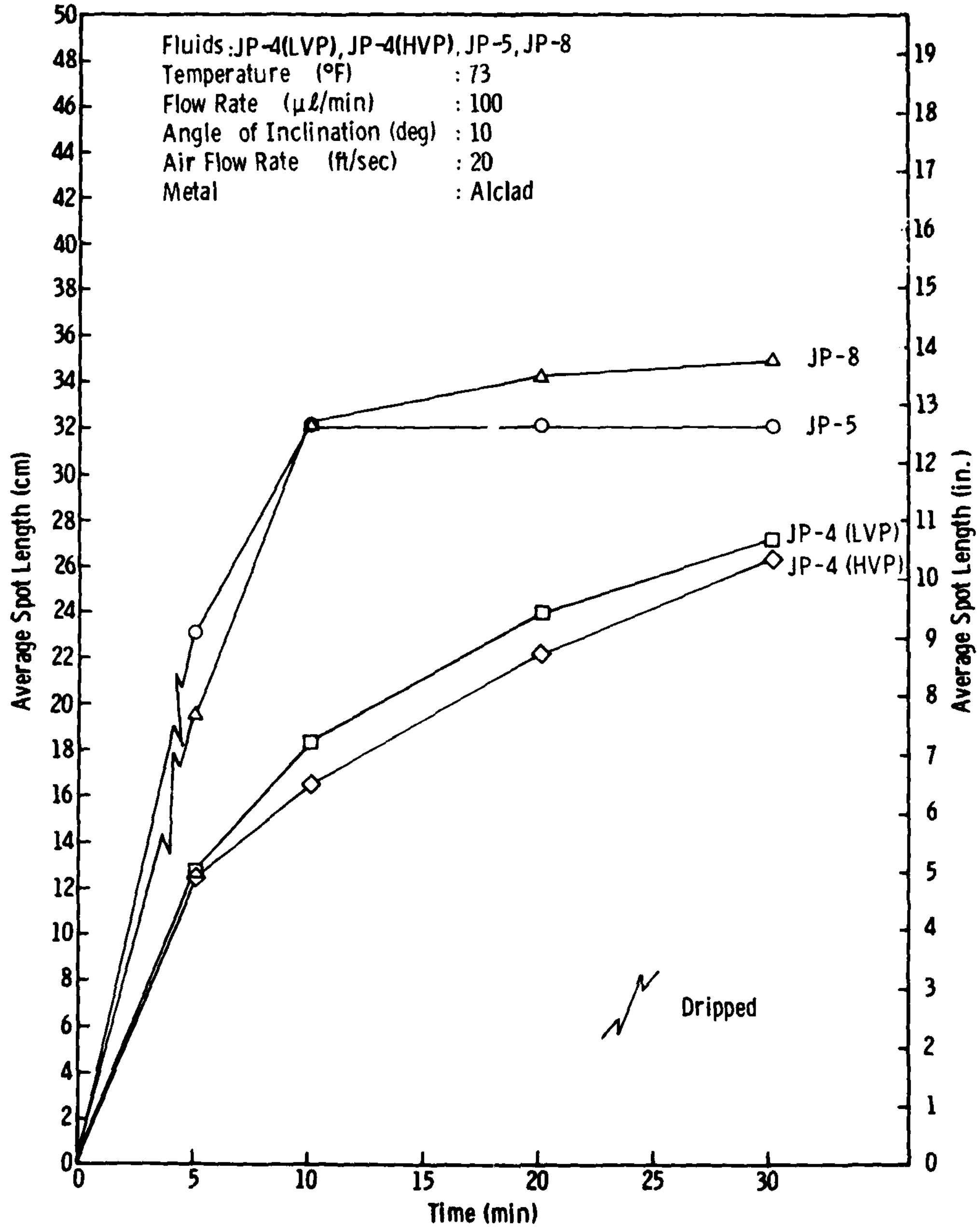
Fluids : JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 5
Air Flow Rate (ft/sec) : 20
Metal : Alclad
JP-8
JP-5
JP-4 (LVP)
JP-4 (HVP)
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 57.



Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angle of Inclination (deg) : 10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
JP-5
JP-8
JP-4 (LVP)
JP-4 (HVP)
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 58.



Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
JP-8
JP-5
JP-4 (LVP)
JP-4 (HVP)
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 59.

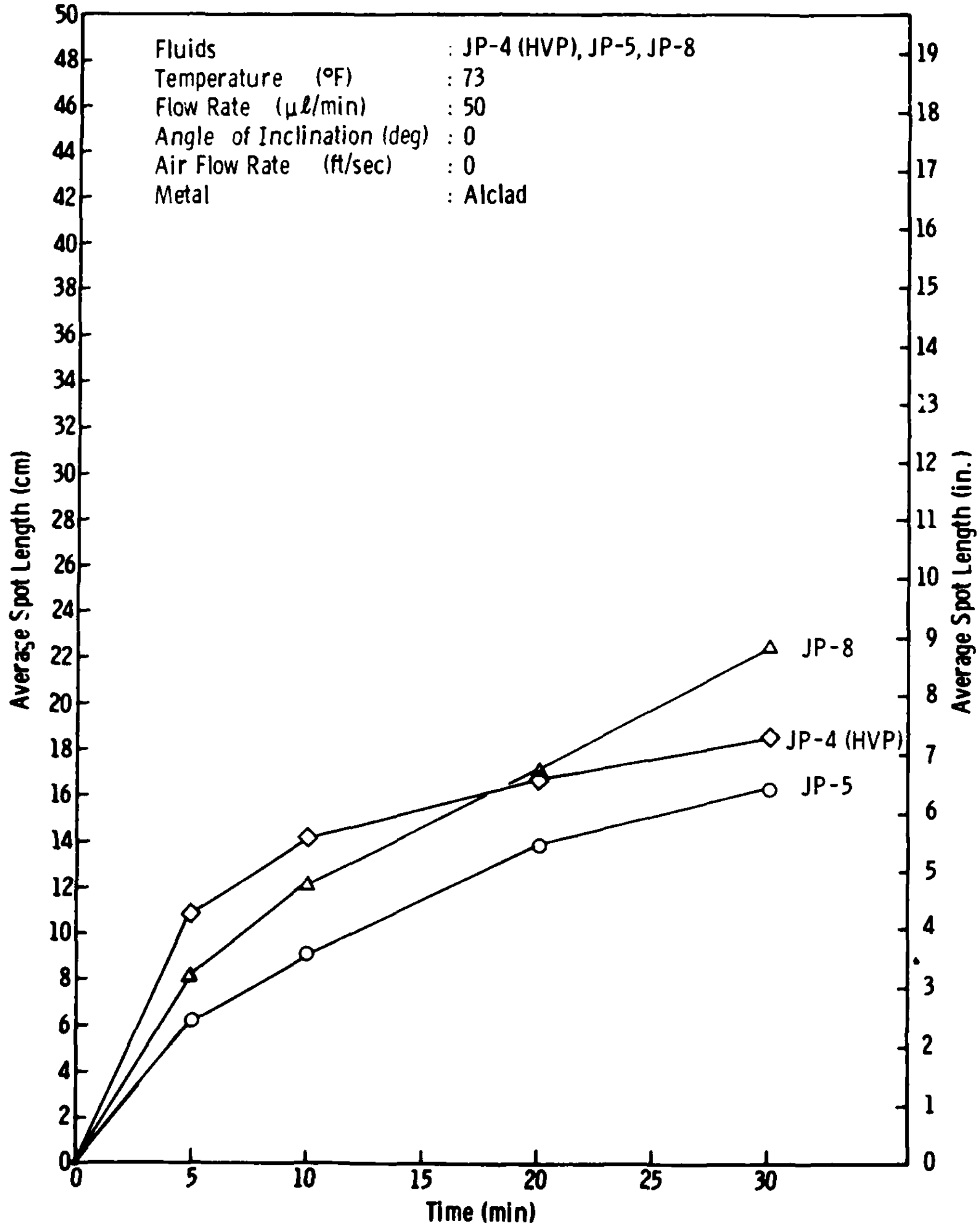

Fluids : JP-4 (HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
JP-8
JP-4 (HVP)
JP-5
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30

Figure 60.

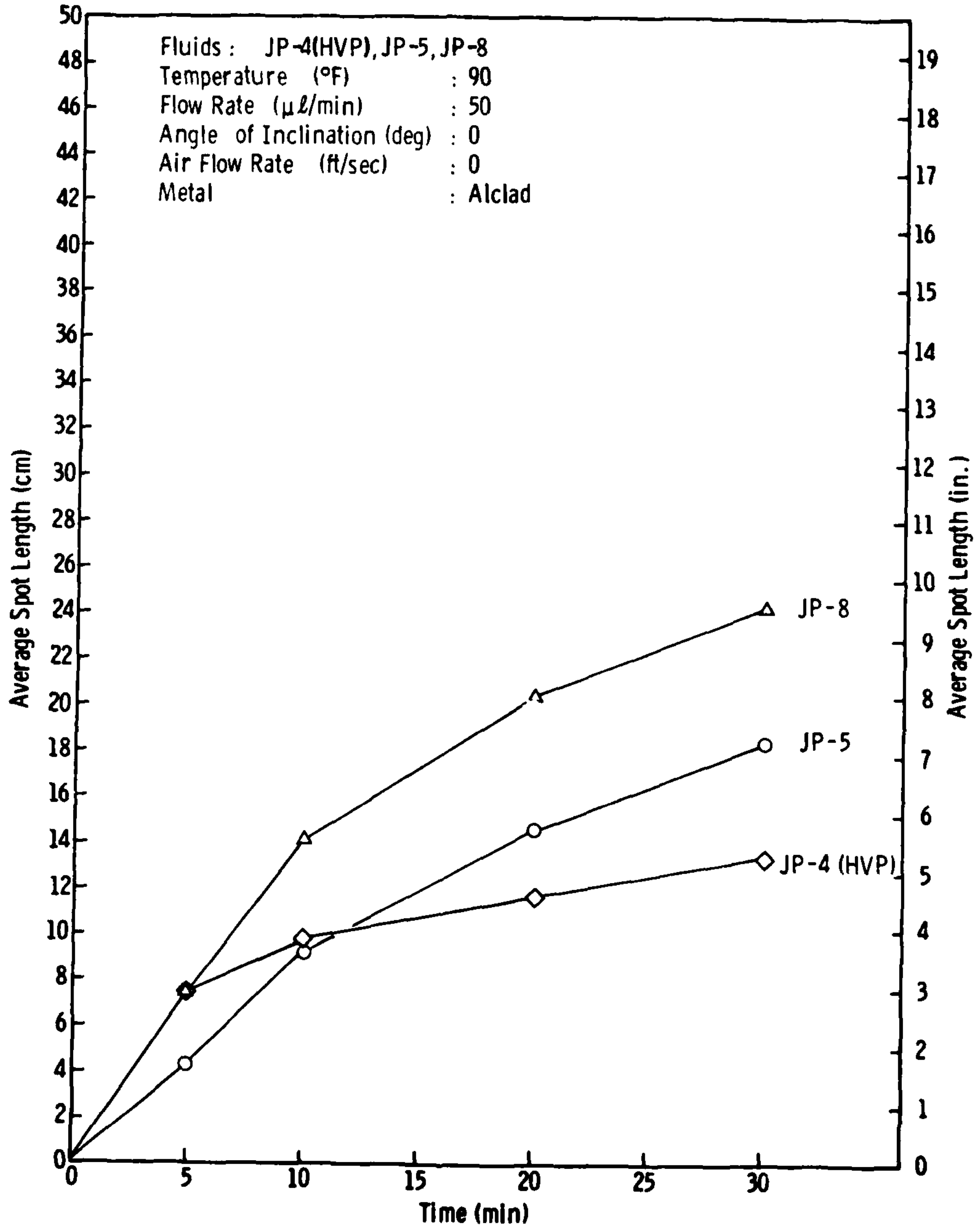

Fluids : JP-4(HVP), JP-5, JP-8
Temperature (°F) : 90
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
JP-8
JP-5
JP-4 (HVP)
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30

Figure 61.

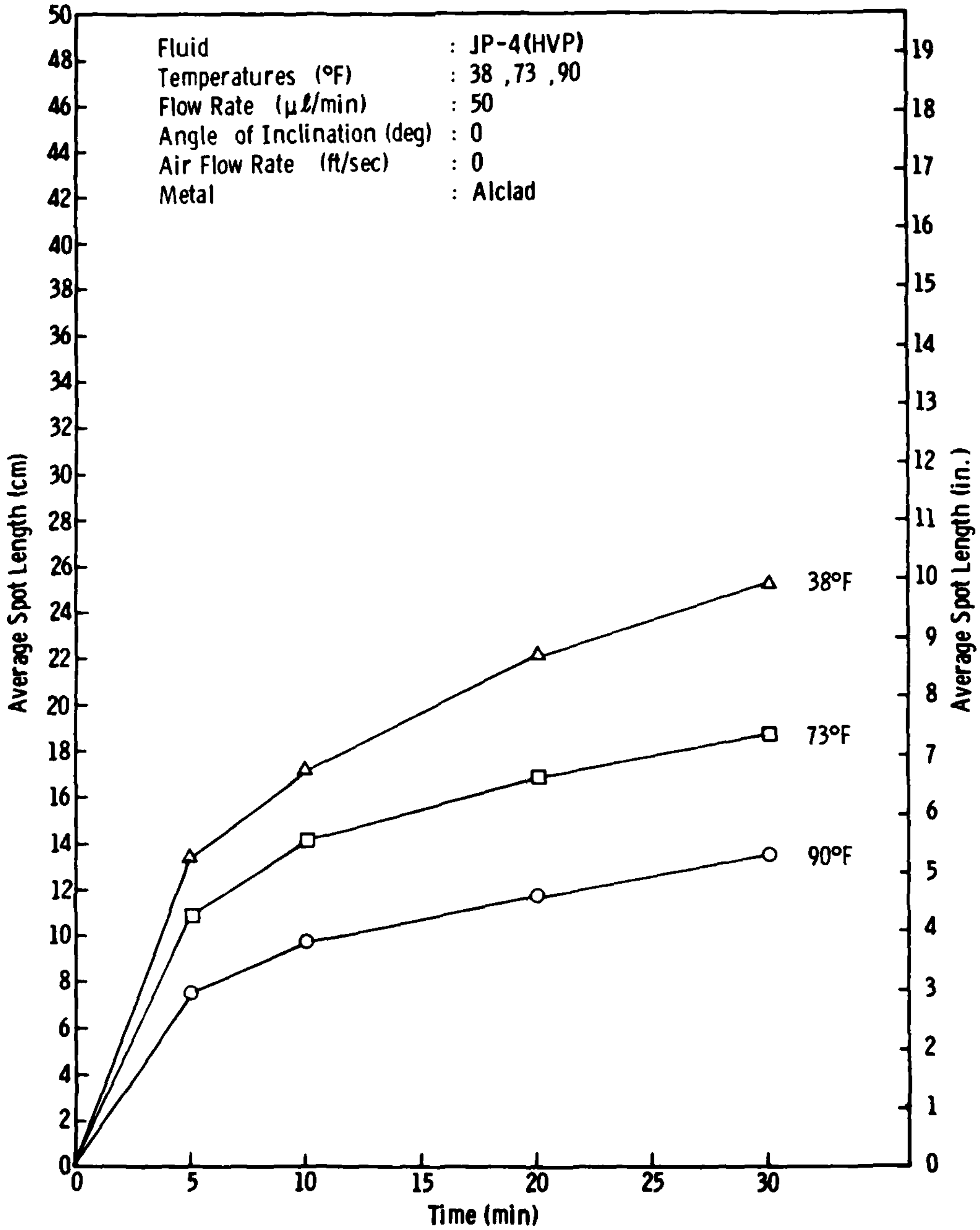

Fluid : JP-4(HVP)
Temperatures (°F) : 38 ,73 ,90
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
38°F
73°F
90°F
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 62.

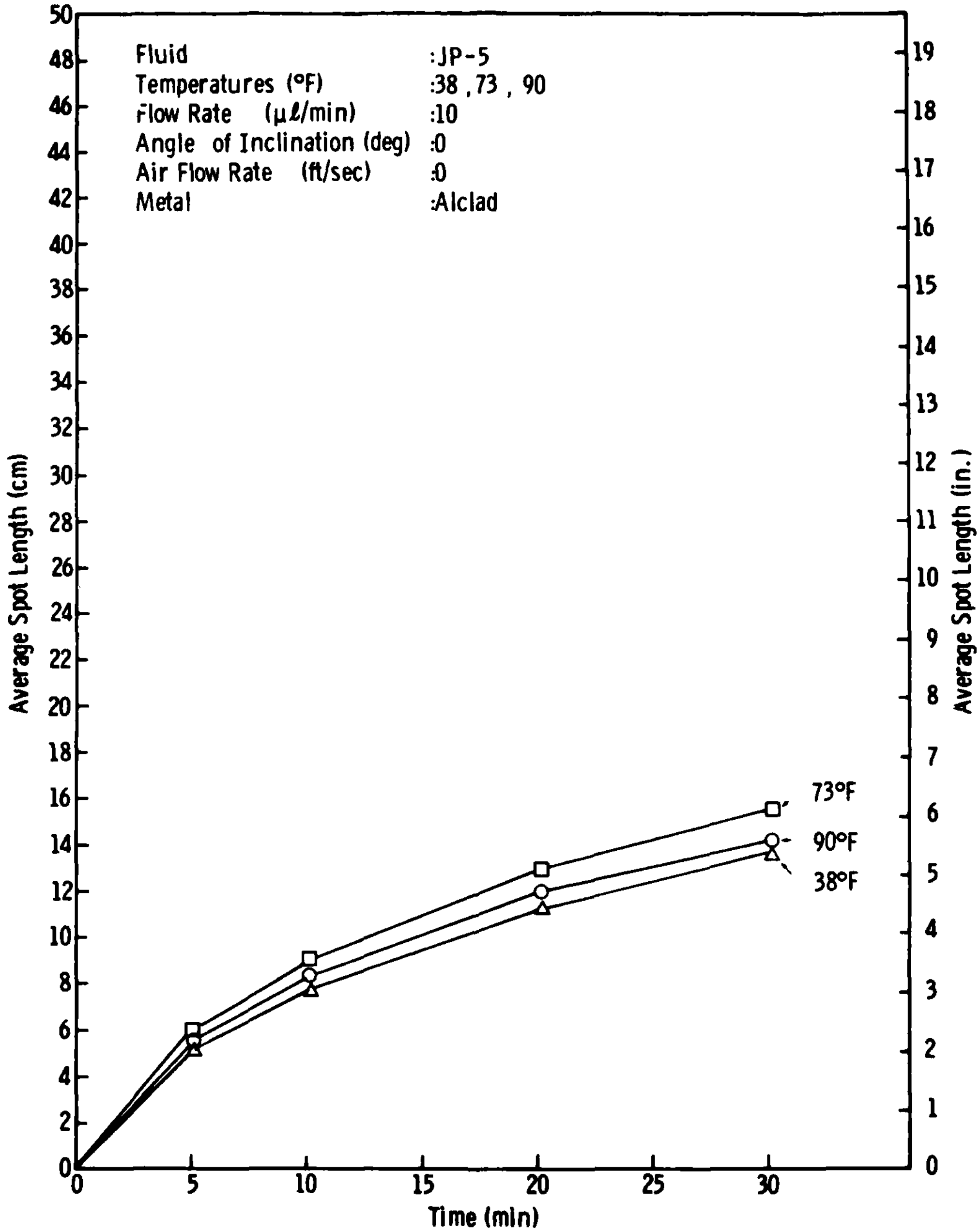

Fluid :JP-5
Temperatures (°F) :38 ,73 , 90
Flow Rate (µℓ/min) :10
Angle of Inclination (deg) :0
Air Flow Rate (ft/sec) :0
Metal :Alclad
73°F
90°F
38°F
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 63.

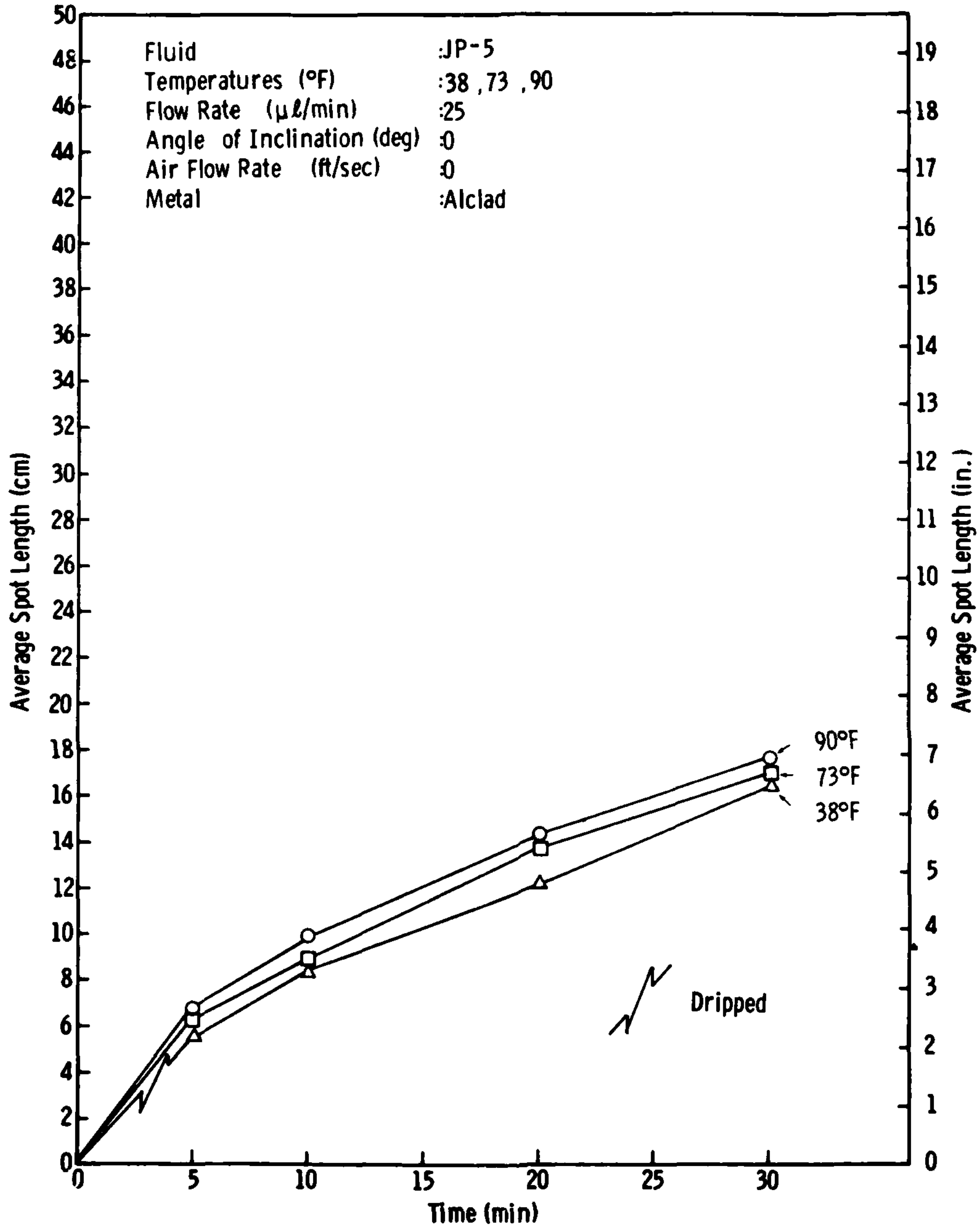

Fluid :JP-5
Temperatures (°F) :38 ,73 ,90
Flow Rate (μℓ/min) :25
Angle of Inclination (deg) :0
Air Flow Rate (ft/sec) :0
Metal :Alclad
90°F
73°F
38°F
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 64.

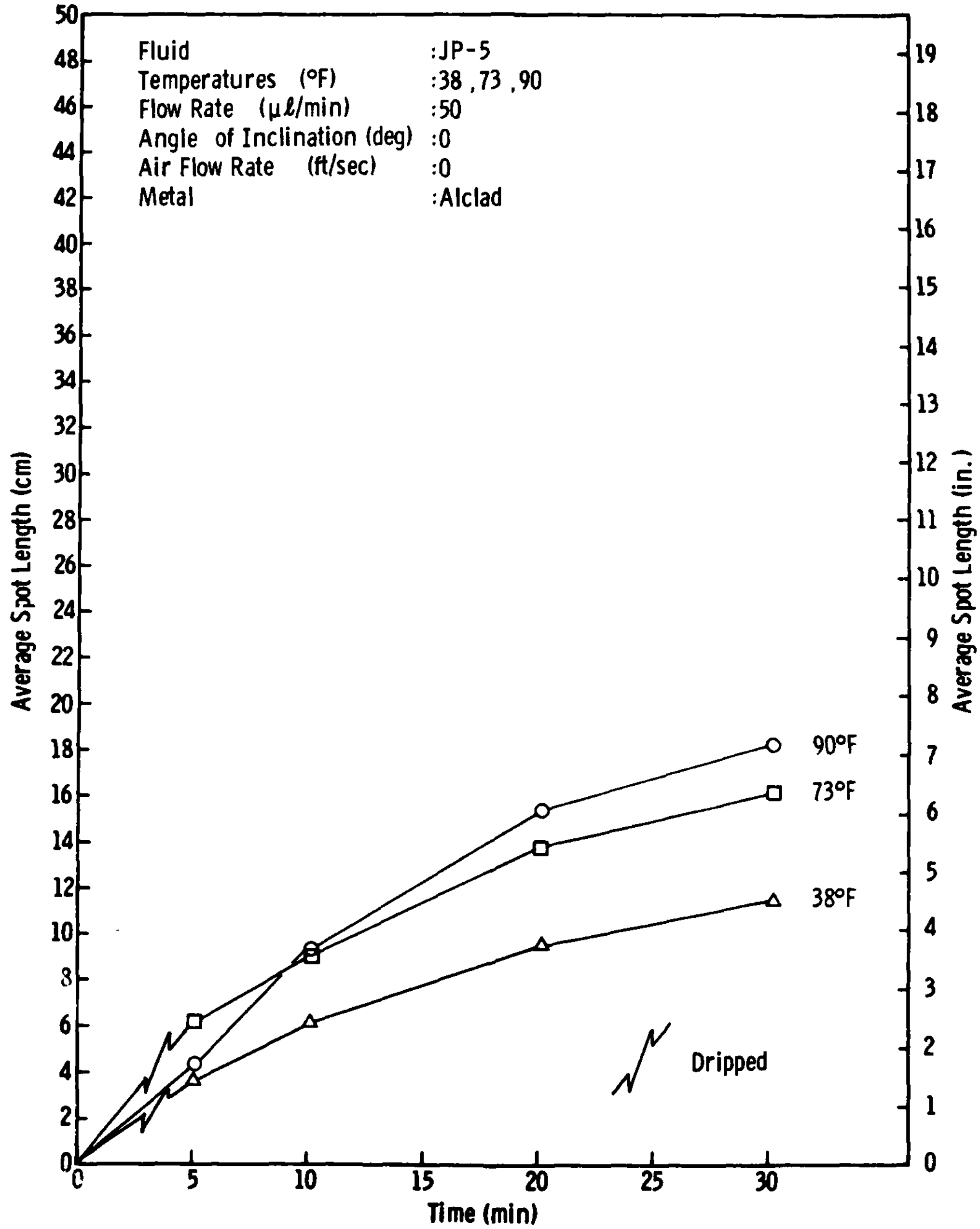
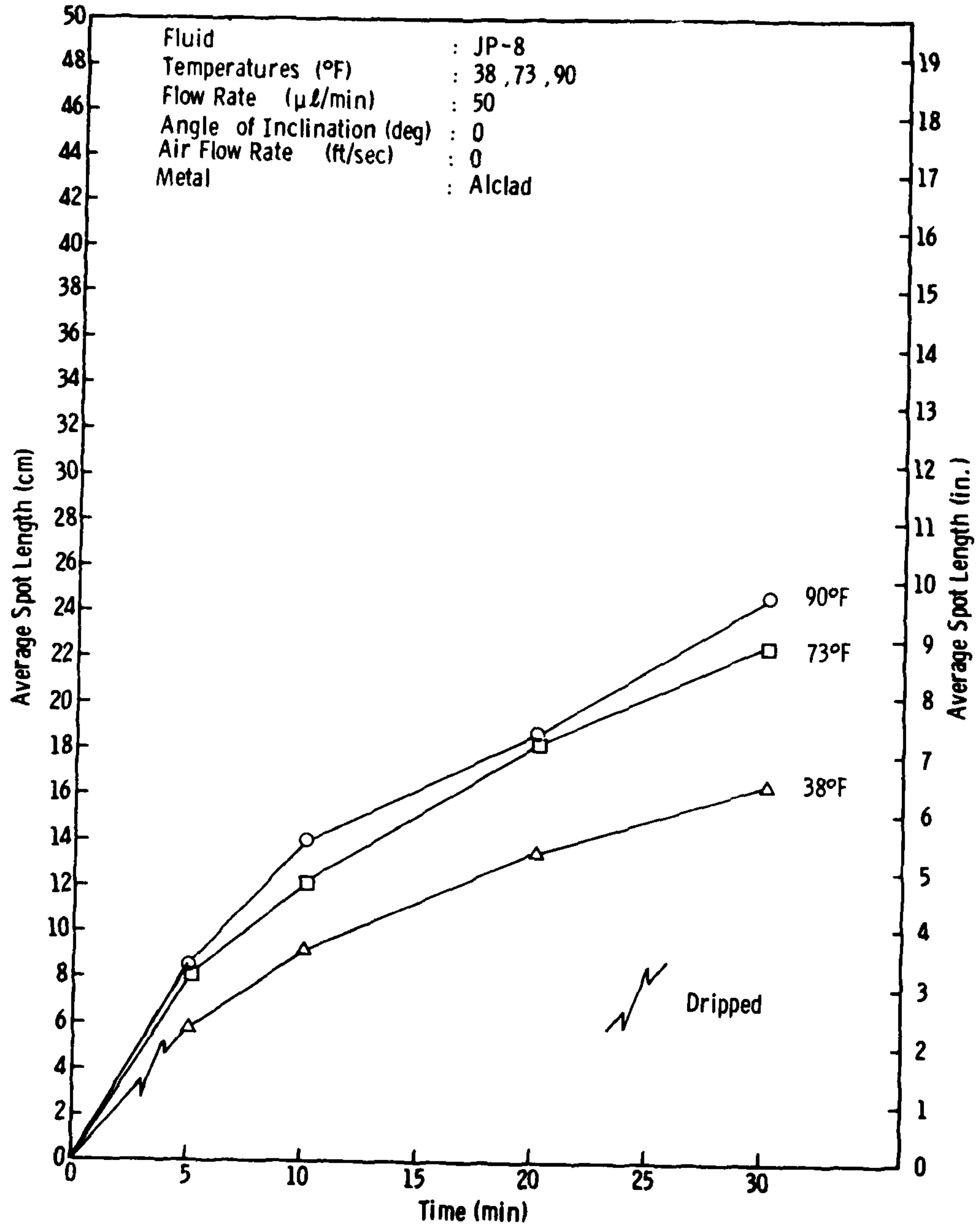

Fluid :JP-5
Temperatures (°F) :38 ,73 ,90
Flow Rate (µℓ/min) :50
Angle of Inclination (deg) :0
Air Flow Rate (ft/sec) :0
Metal :Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
90°F
73°F
38°F
Dripped

Figure 65.



Fluid : JP-8
Temperatures (°F) : 38, 73, 90
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 0
Metal : Alclad
90°F
73°F
38°F
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 66.

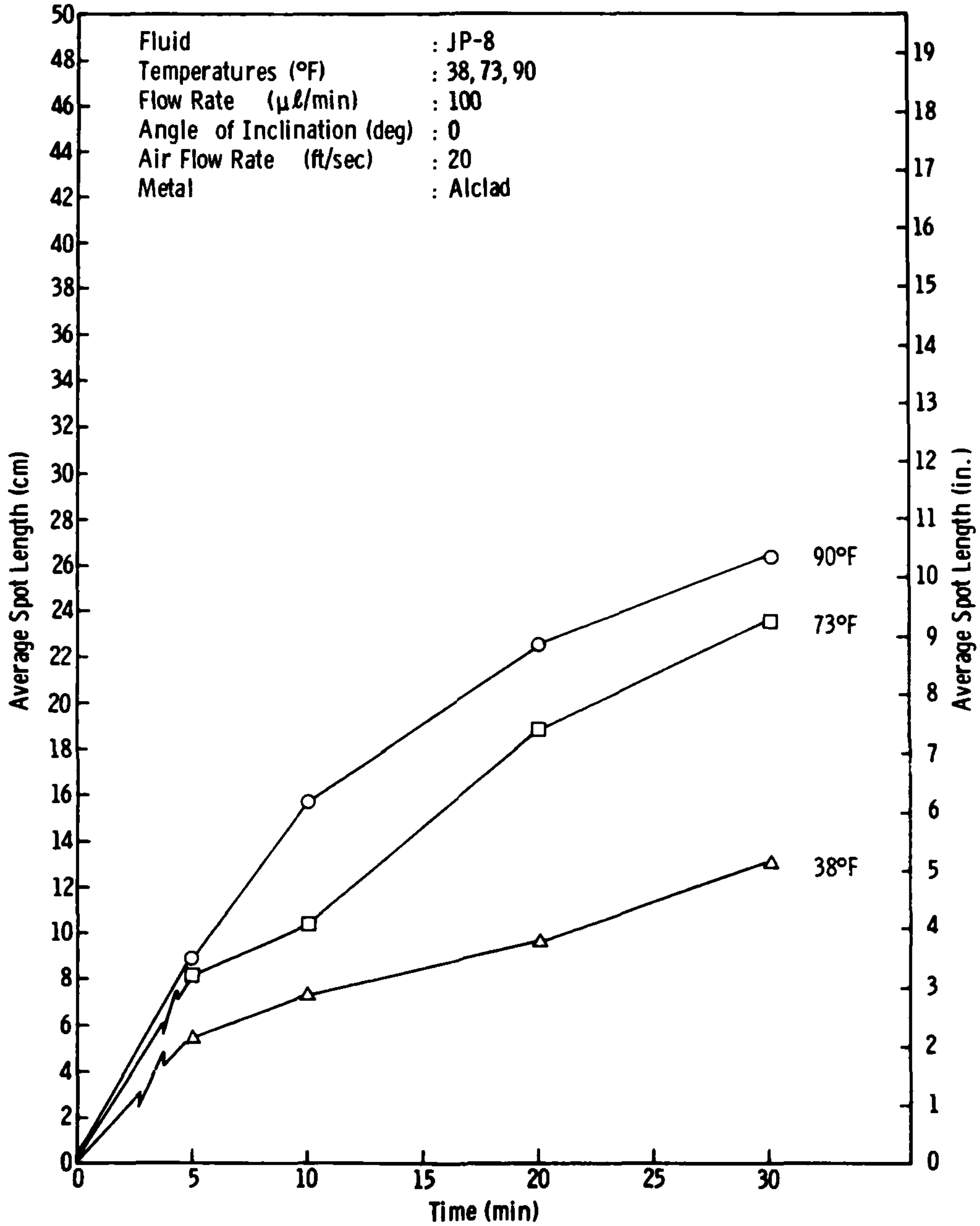

Fluid : JP-8
Temperatures (°F) : 38, 73, 90
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Alclad
90°F
73°F
38°F
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30

Figure 67.

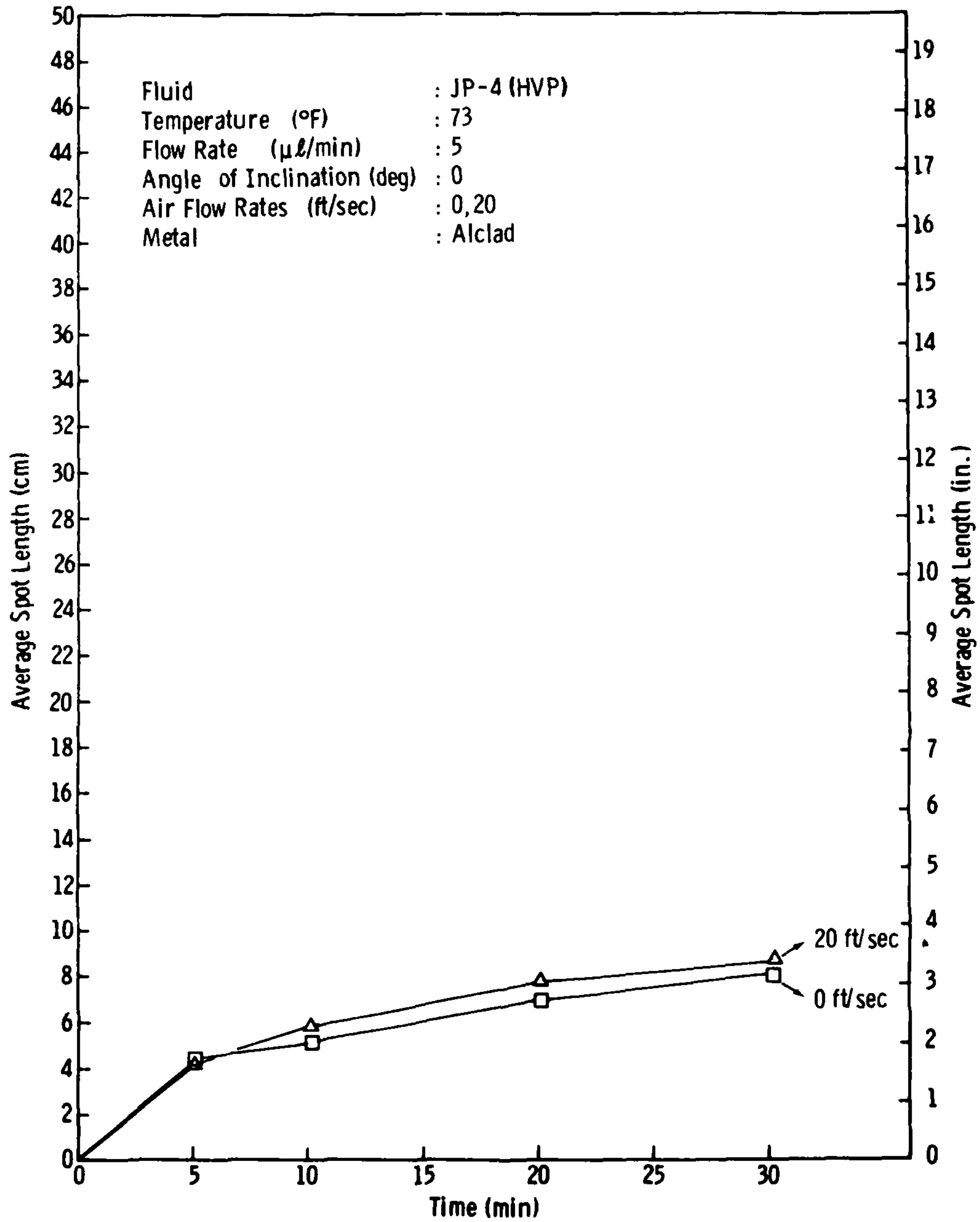

Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 5
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 0,20
Metal : Alclad
20 ft/sec
0 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 68.

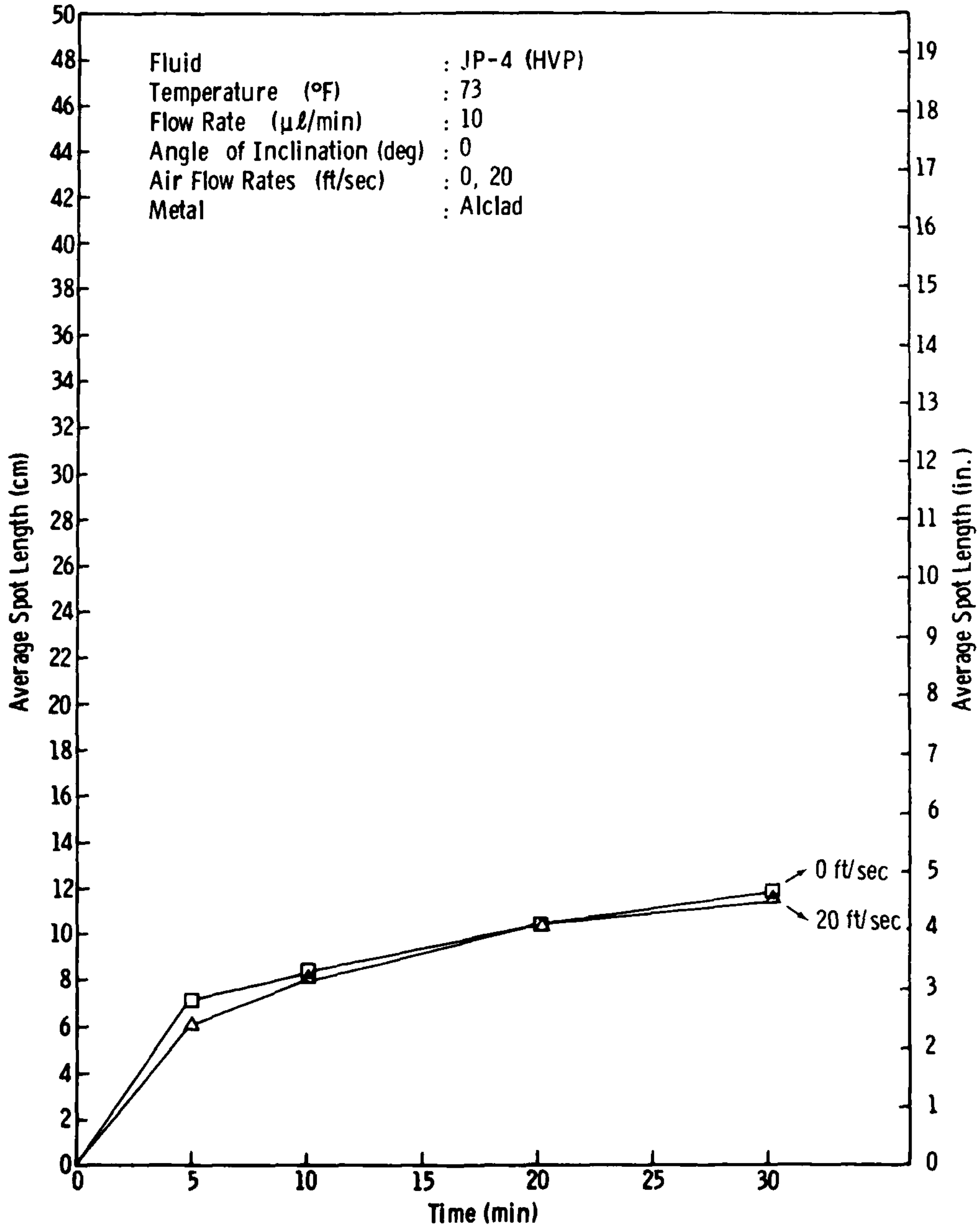
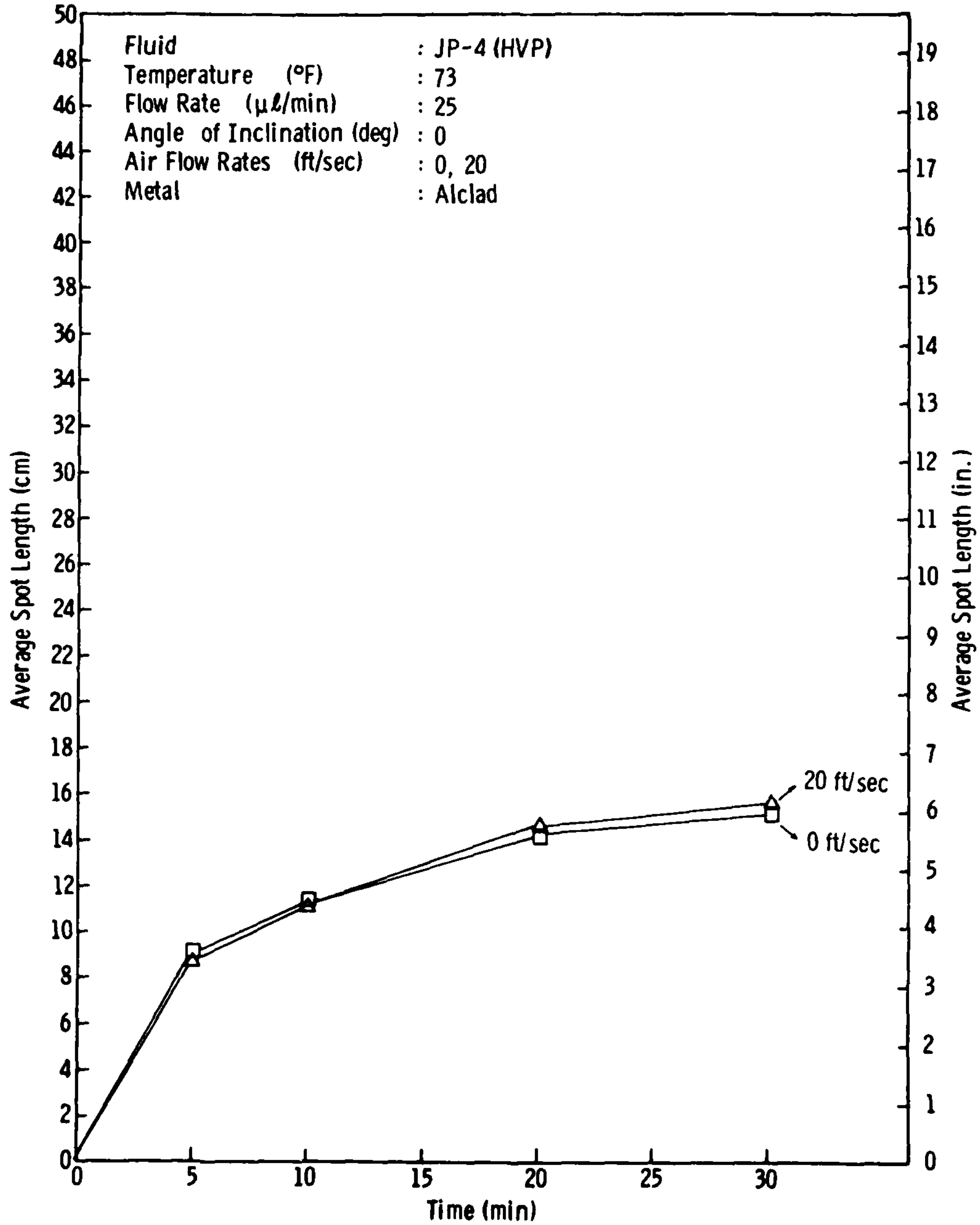
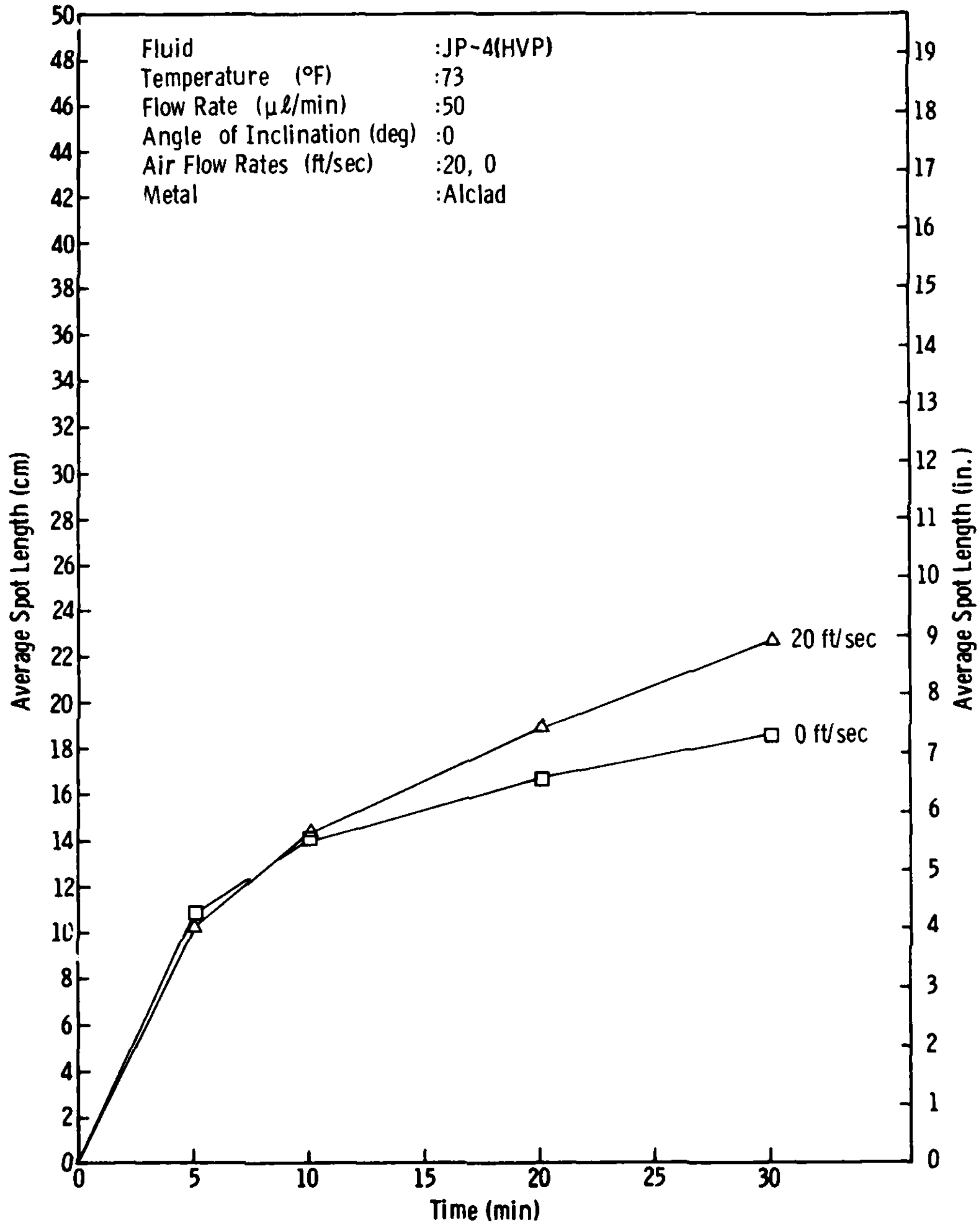

Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 0, 20
Metal : Alclad
0 ft/sec
20 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30

Figure 69.



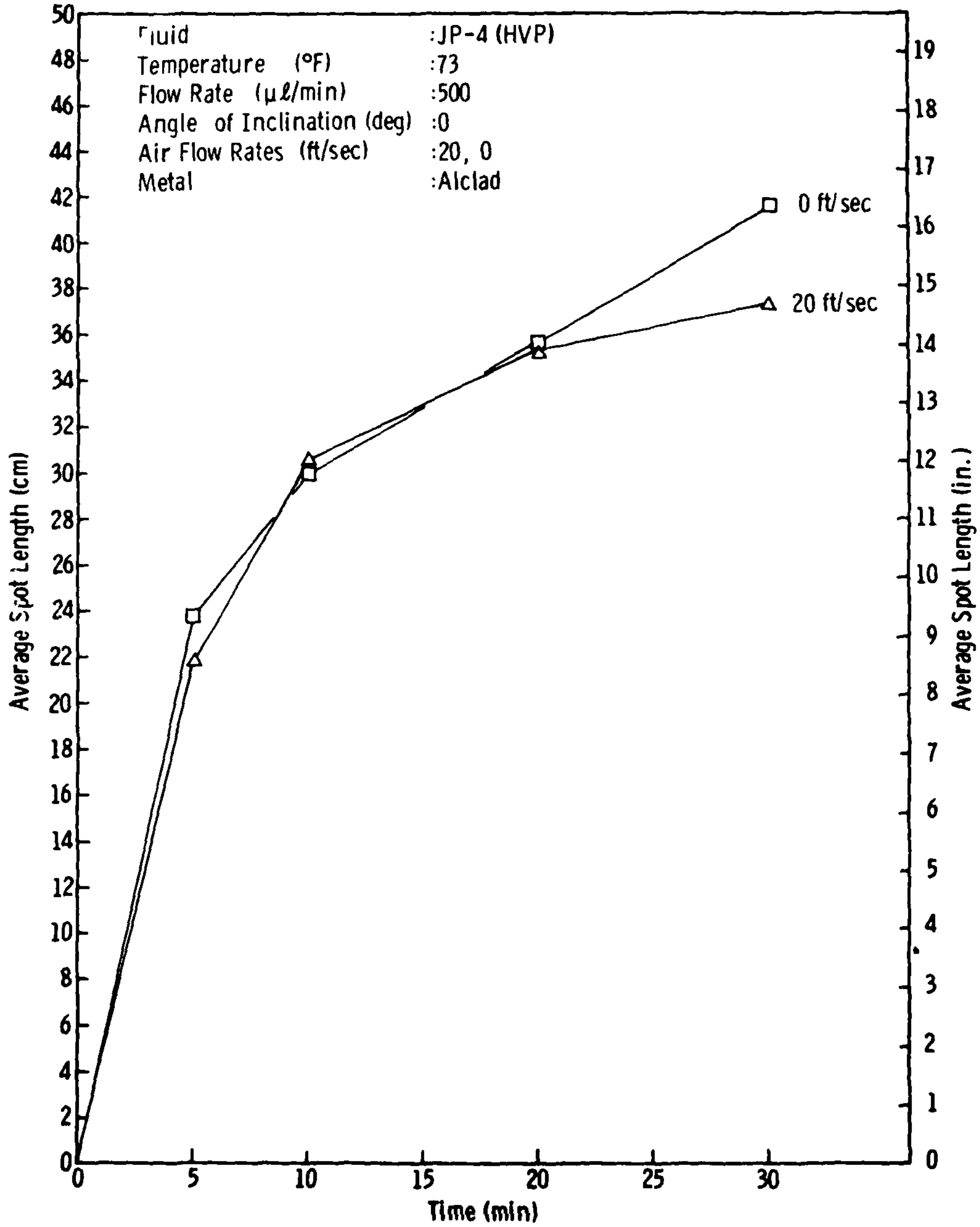
Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 25
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 0, 20
Metal : Alclad
20 ft/sec
0 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 70.



Fluid :JP-4(HVP)
Temperature (°F) :73
Flow Rate (μℓ/min) :50
Angle of Inclination (deg) :0
Air Flow Rates (ft/sec) :20, 0
Metal :Alclad
20 ft/sec
0 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 71.



Fluid :JP-4 (HVP)
Temperature (°F) :73
Flow Rate (µℓ/min) :500
Angle of Inclination (deg) :0
Air Flow Rates (ft/sec) :20, 0
Metal :Alclad
0 ft/sec
20 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 72.

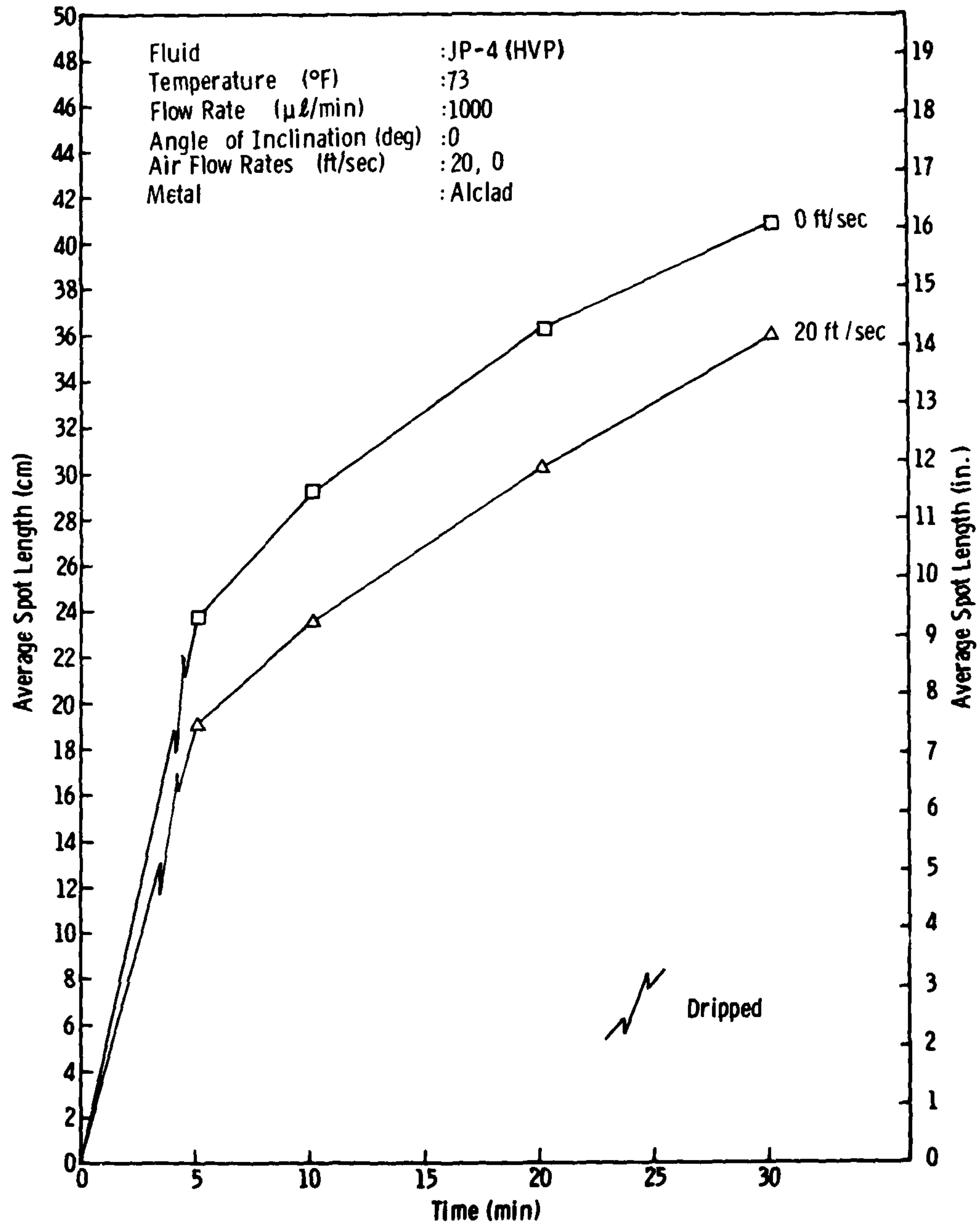

Fluid :JP-4 (HVP)
Temperature (°F) :73
Flow Rate (μℓ/min) :1000
Angle of Inclination (deg) :0
Air Flow Rates (ft/sec) :20, 0
Metal :Alclad
0 ft/sec
20 ft /sec
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 73.

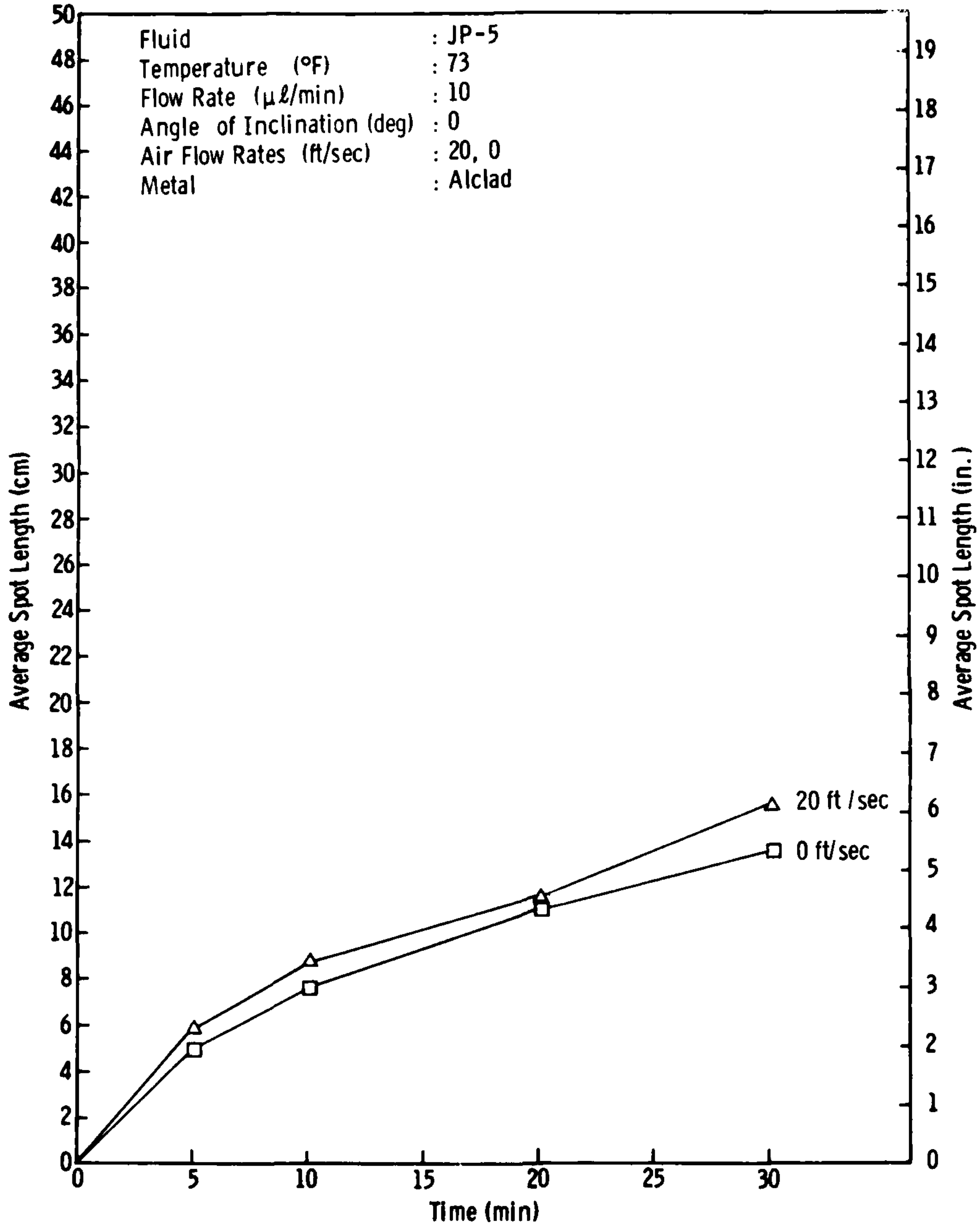
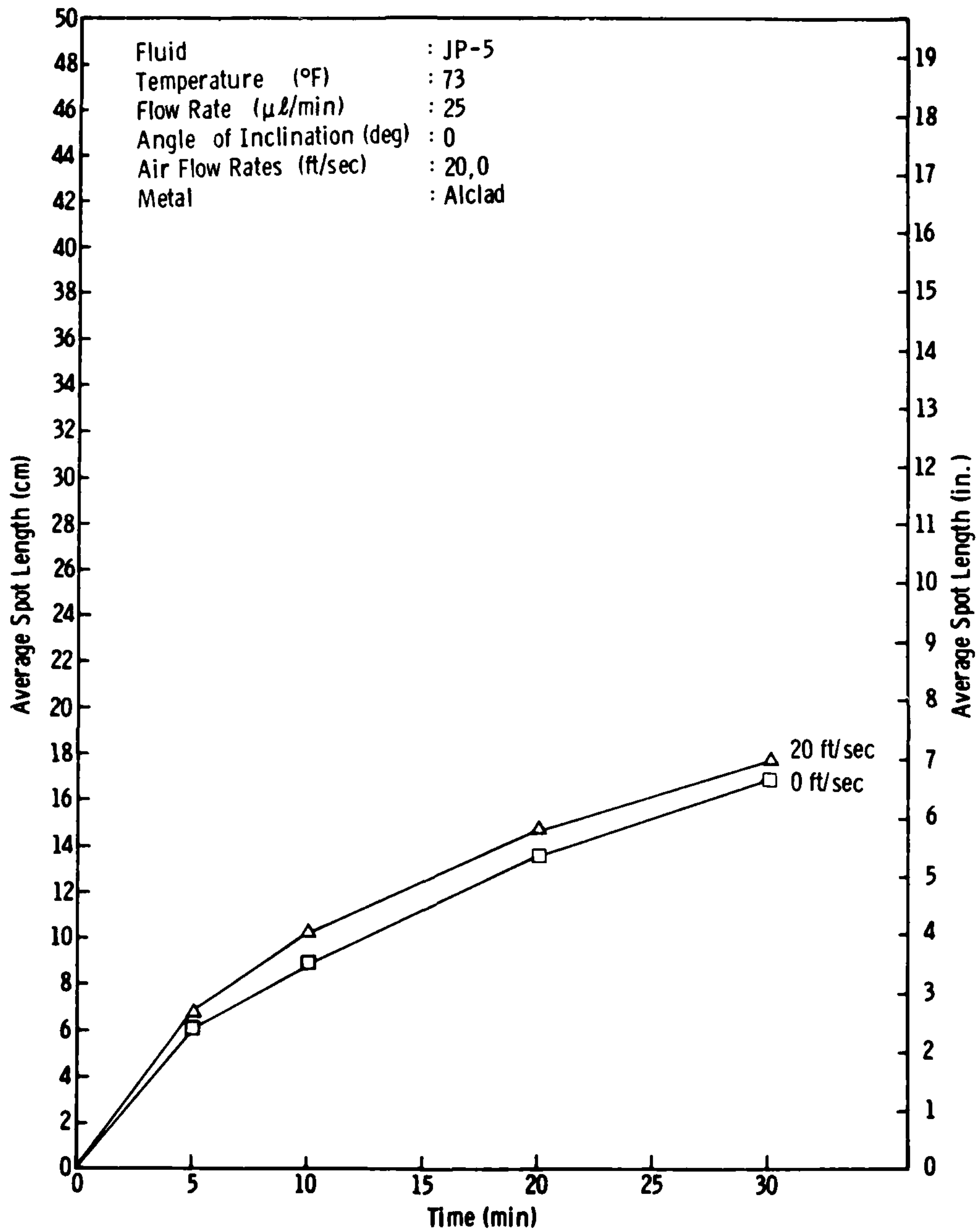
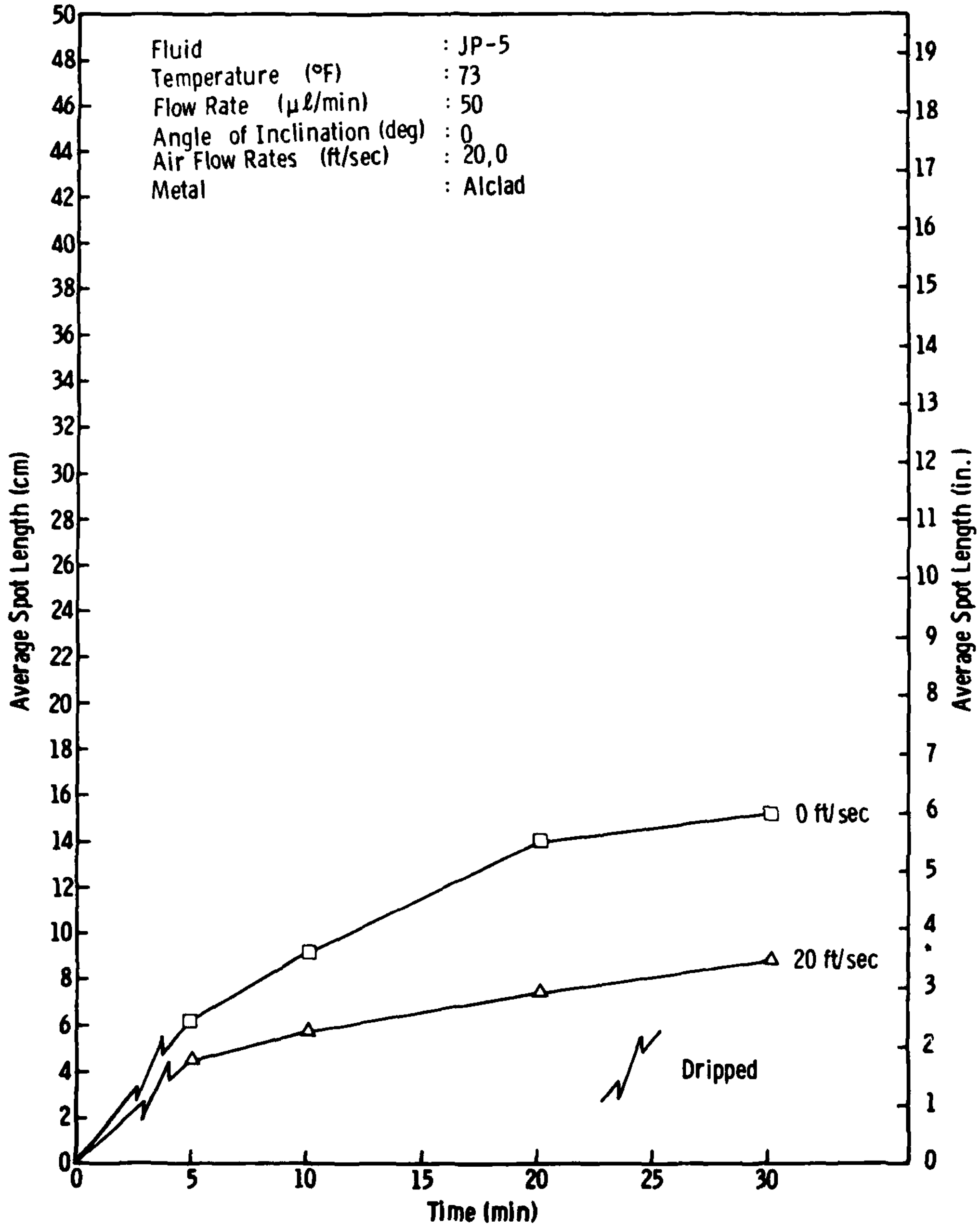

Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 20, 0
Metal : Alclad
20 ft / sec
0 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 74.



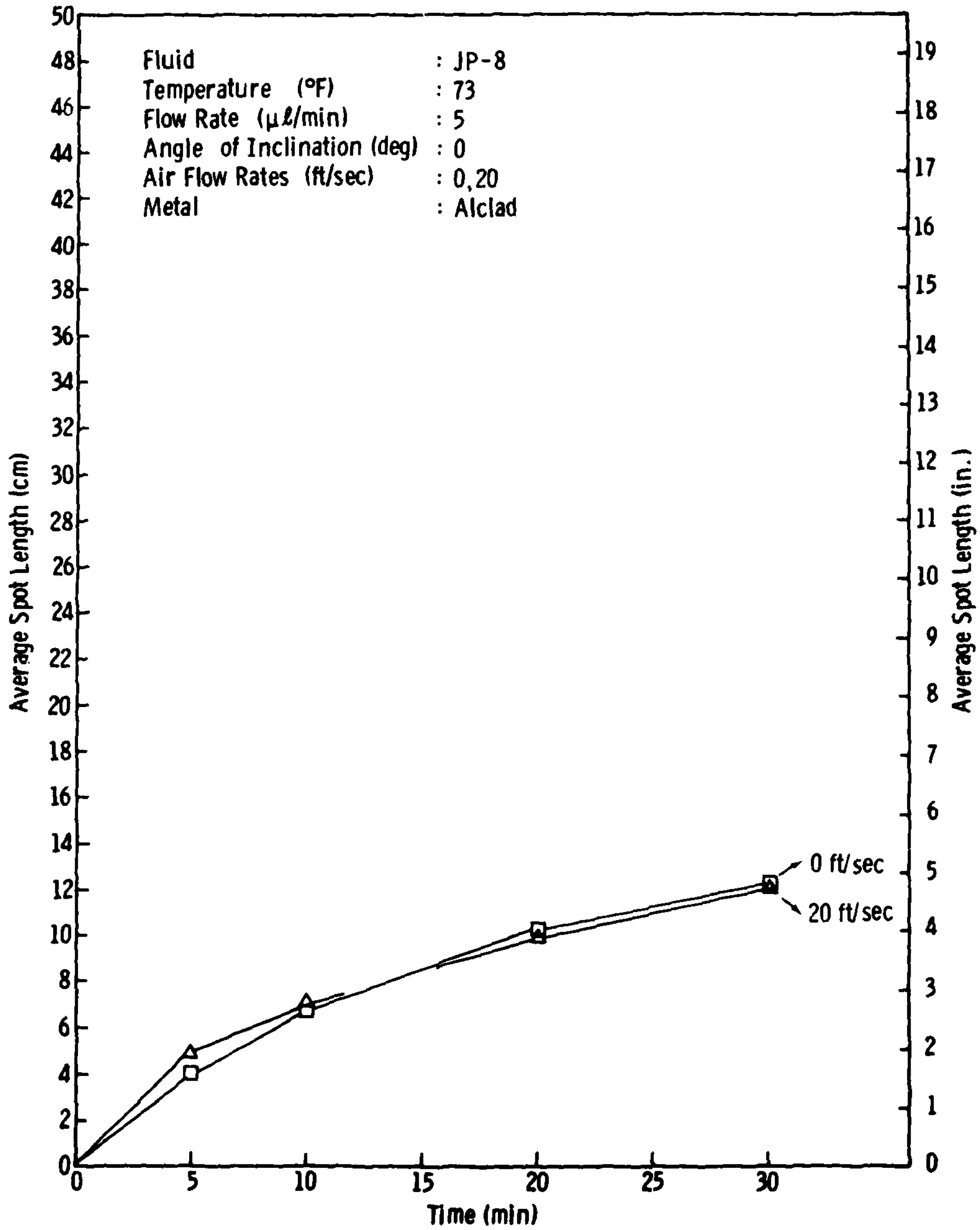
Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 25
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 20,0
Metal : Alclad
20 ft/sec
0 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 75.



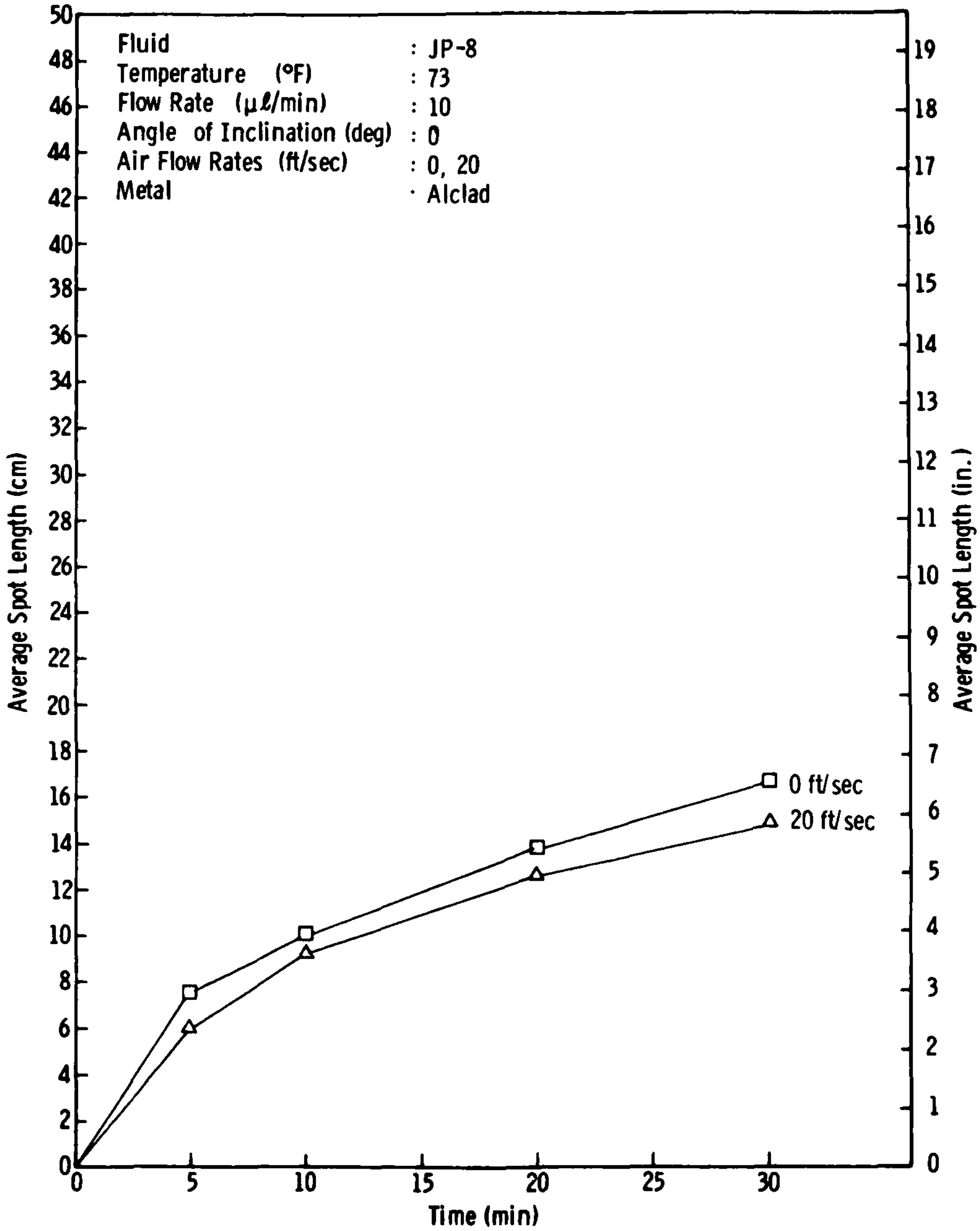
Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 20,0
Metal : Alclad
0 ft/sec
20 ft/sec
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
3
5
7
9
11
13
15
17
19
25


Figure 76.



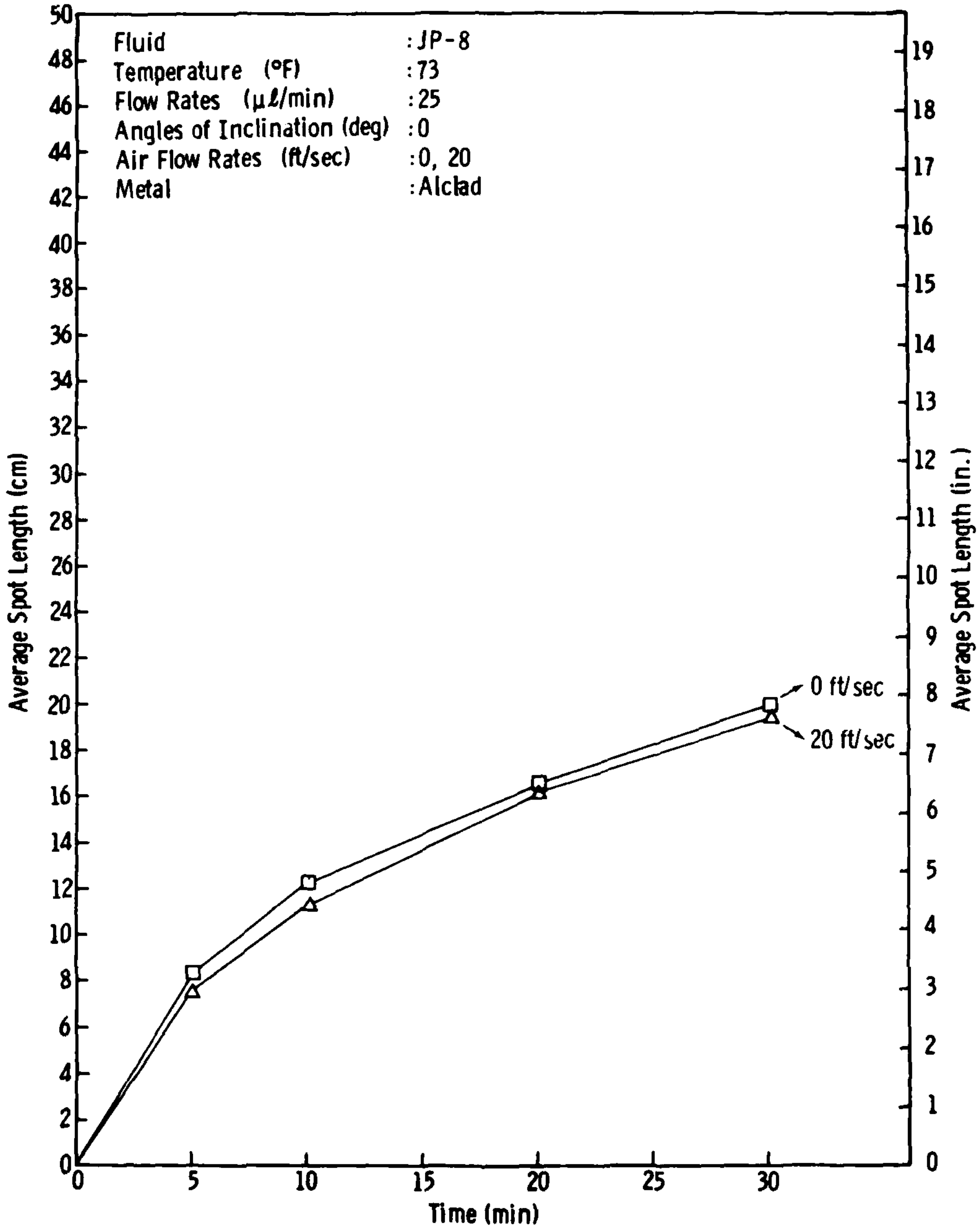
Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 5
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 0,20
Metal : Alclad
0 ft/sec
20 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 77.



Fluid : JP-8
Temperature (°F) : 73
Flow Rate (µℓ/min) : 10
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 0, 20
Metal · Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0 ft/sec
20 ft/sec
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
5
10
15
20
25
30


Figure 78.



Fluid :JP-8
Temperature (°F) :73
Flow Rates (μℓ/min) :25
Angles of Inclination (deg) :0
Air Flow Rates (ft/sec) :0, 20
Metal :Alclad
0 ft/sec
20 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 79.

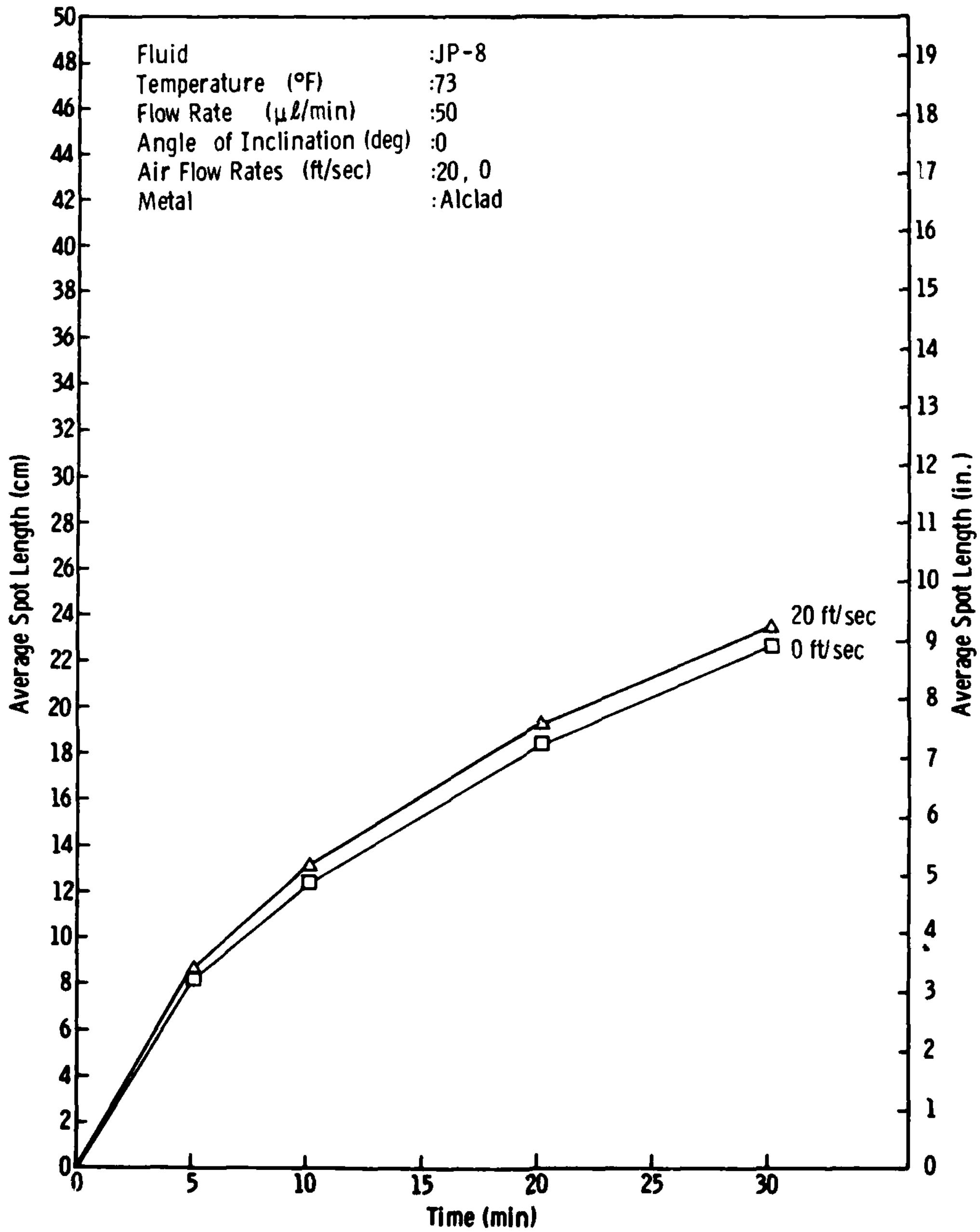

Fluid :JP-8
Temperature (°F) :73
Flow Rate (μℓ/min) :50
Angle of Inclination (deg) :0
Air Flow Rates (ft/sec) :20, 0
Metal :Alclad
20 ft/sec
0 ft/sec
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
5
10
15
20
25
30

Figure 80.

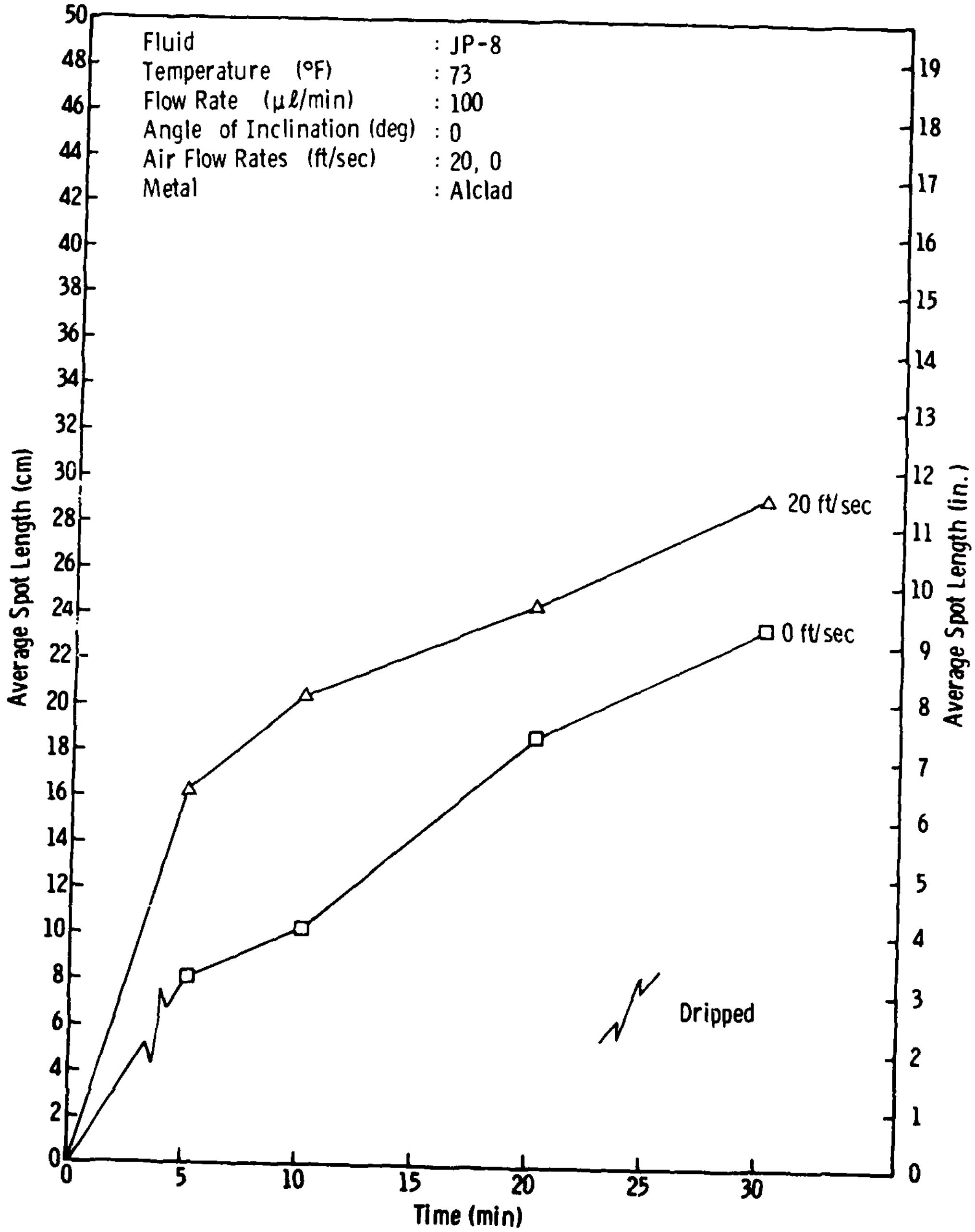
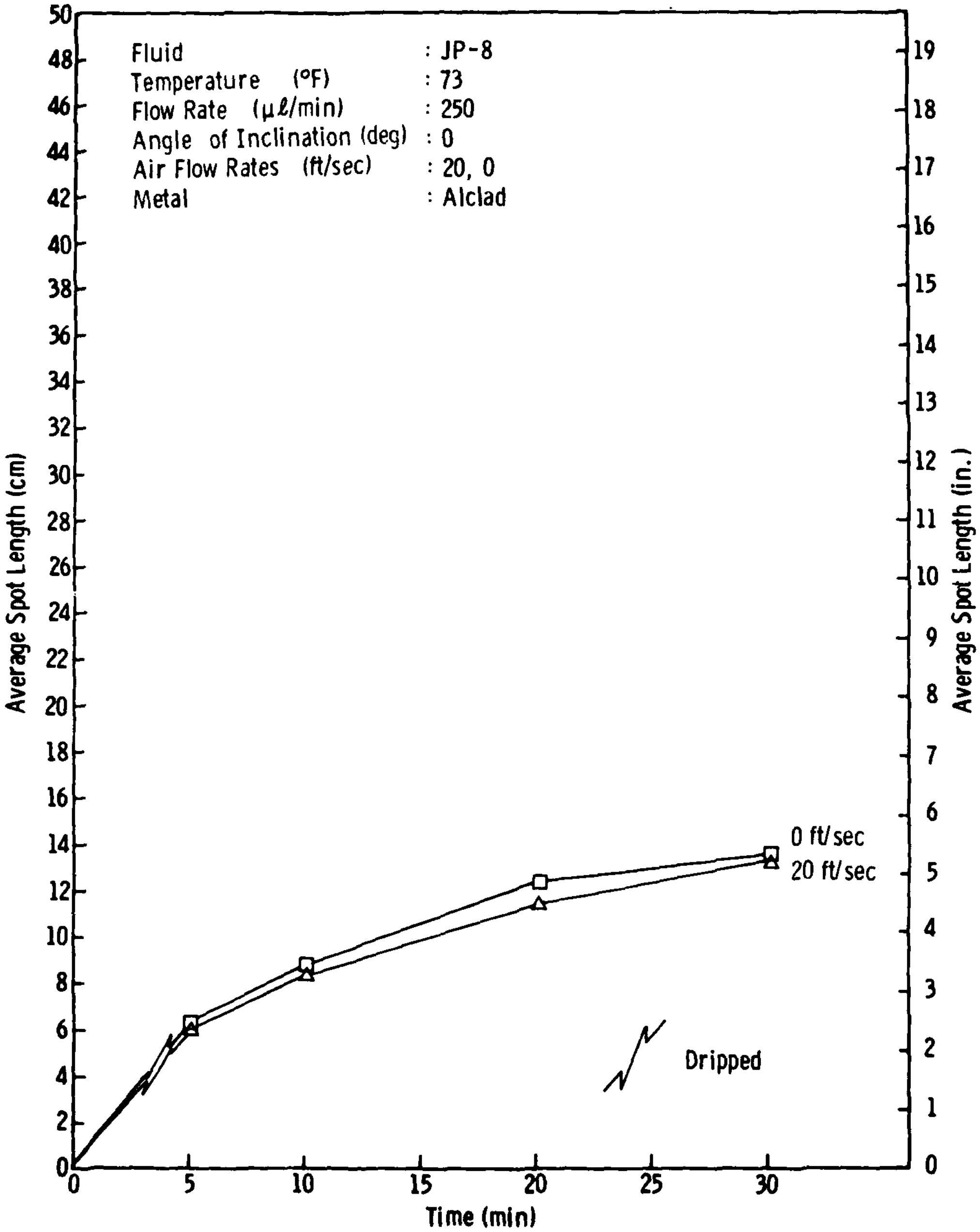
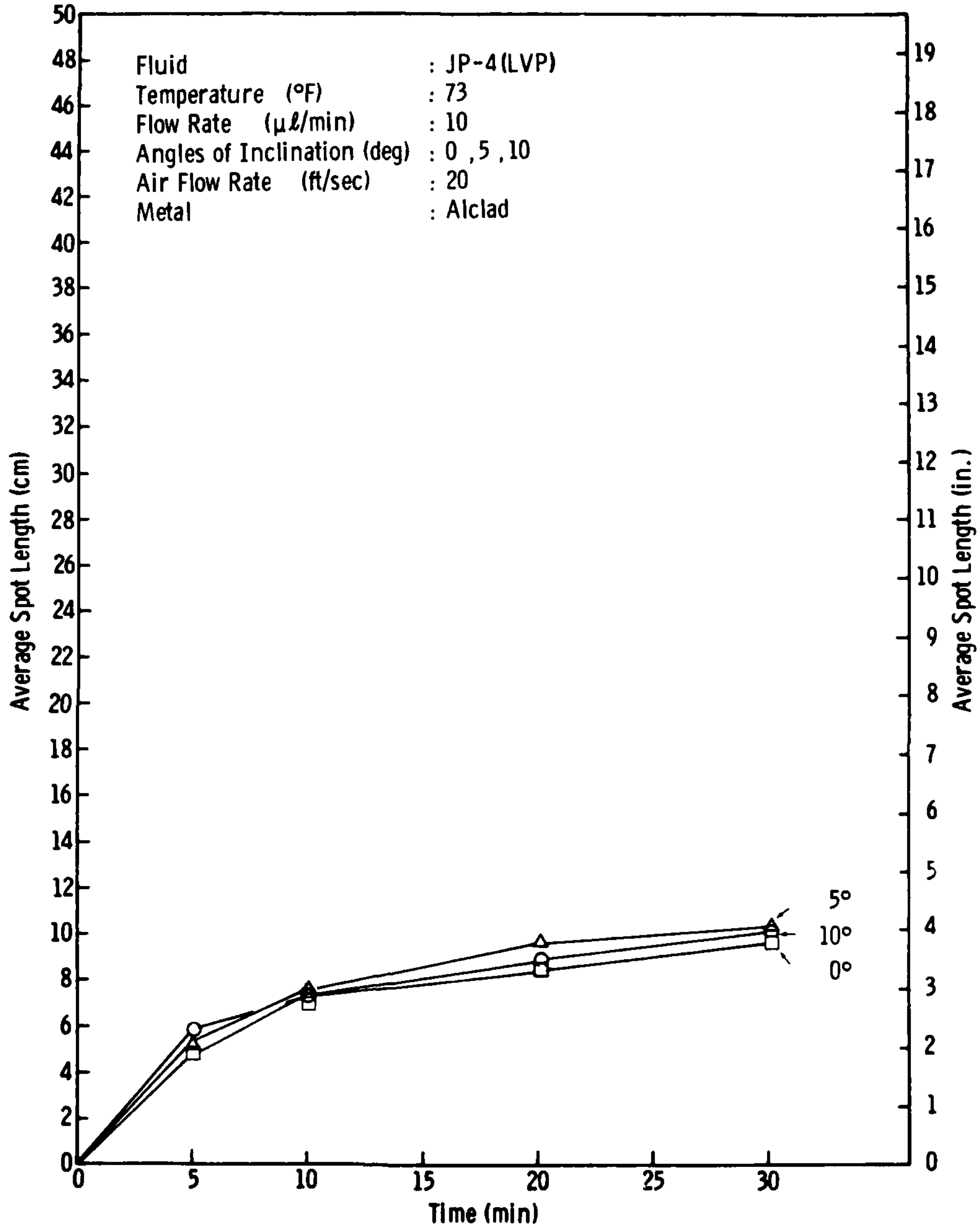

Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 20, 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
20 ft/sec
0 ft/sec
Dripped
Time (min)
0
5
10
15
20
25
30
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

Figure 81.



Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 250
Angle of Inclination (deg) : 0
Air Flow Rates (ft/sec) : 20, 0
Metal : Alclad
0 ft/sec
20 ft/sec
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 82.



Fluid : JP-4(LVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
5°
10°
0°
0
5
10
15
20
25
30


Figure 83.

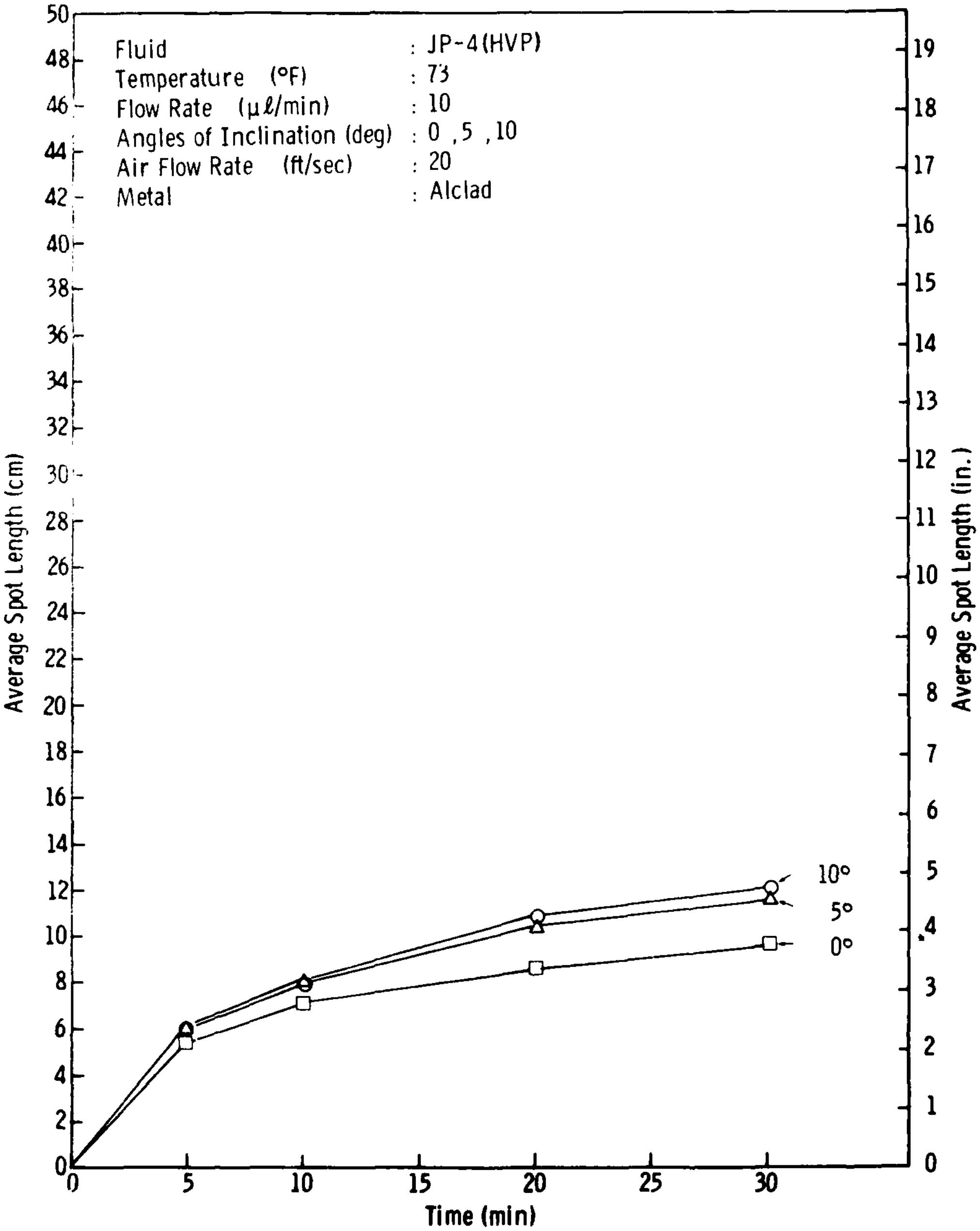

Fluid : JP-4(HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
10°
5°
0°
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30

Figure 84.

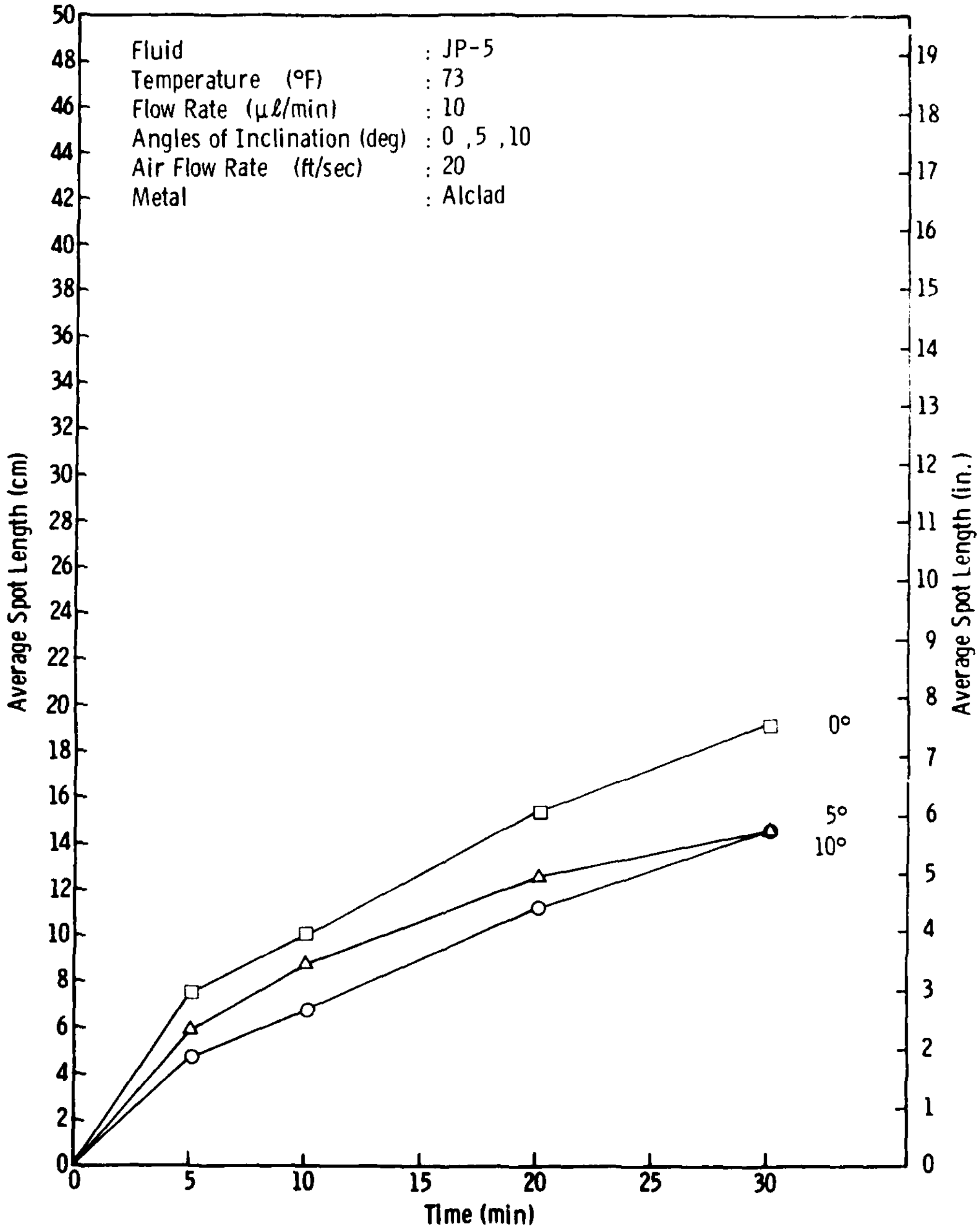

Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0°
5°
10°

Figure 85.

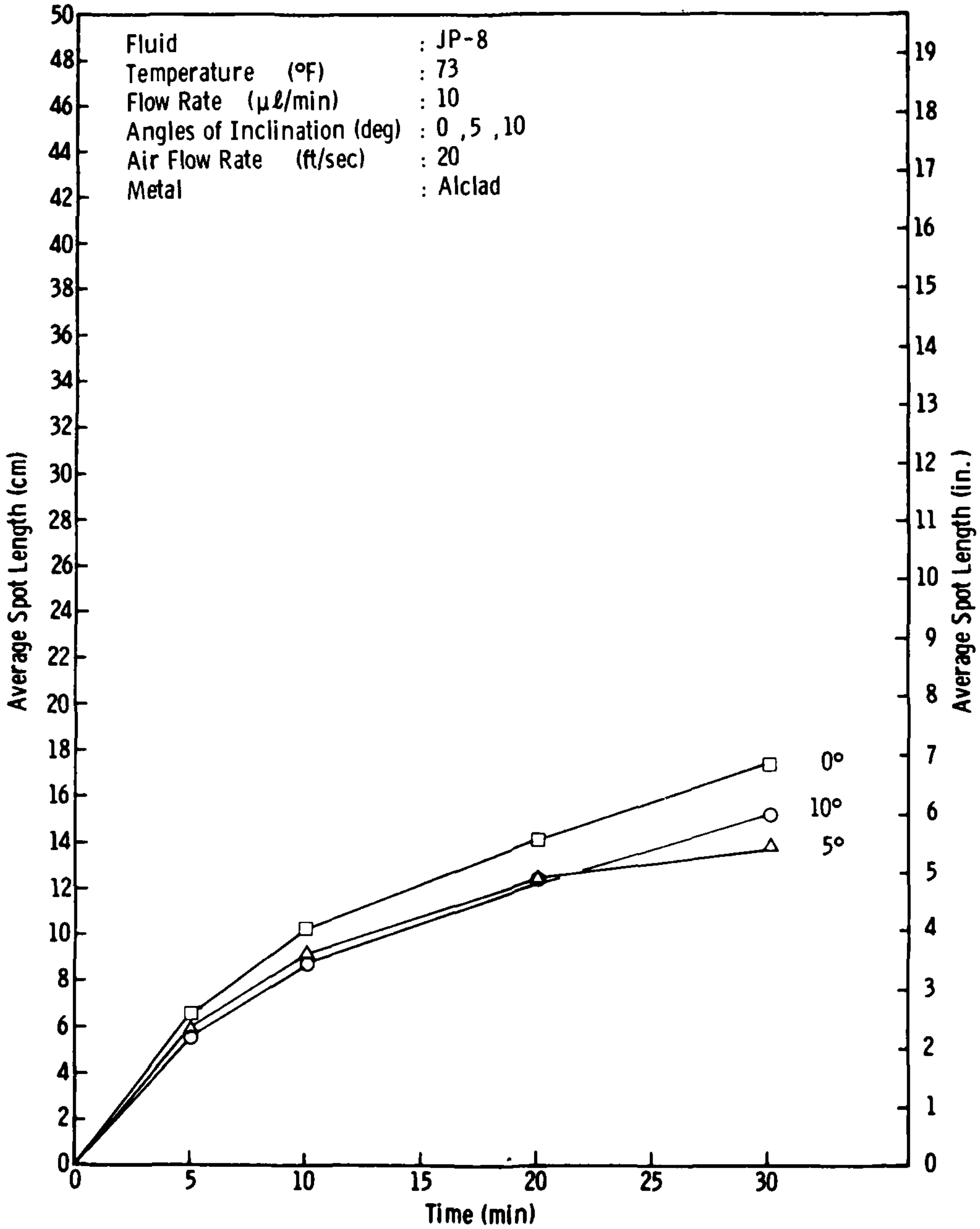

Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0°
10°
5°
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
3
5
7
9
11
13
15
17
19
25

Figure 86.

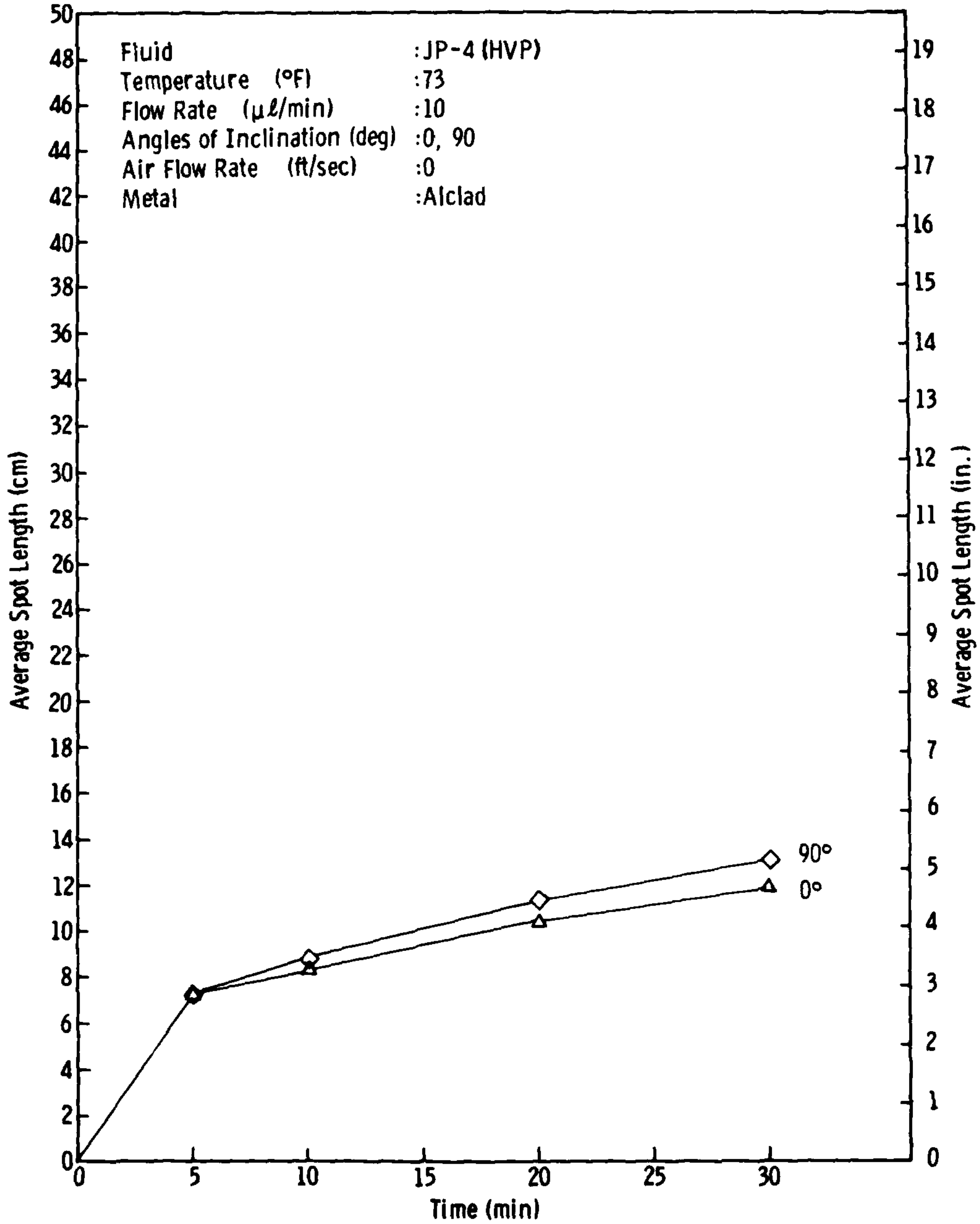

Fluid :JP-4 (HVP)
Temperature (°F) :73
Flow Rate (μℓ/min) :10
Angles of Inclination (deg) :0, 90
Air Flow Rate (ft/sec) :0
Metal :Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
90°
0°

Figure 87.

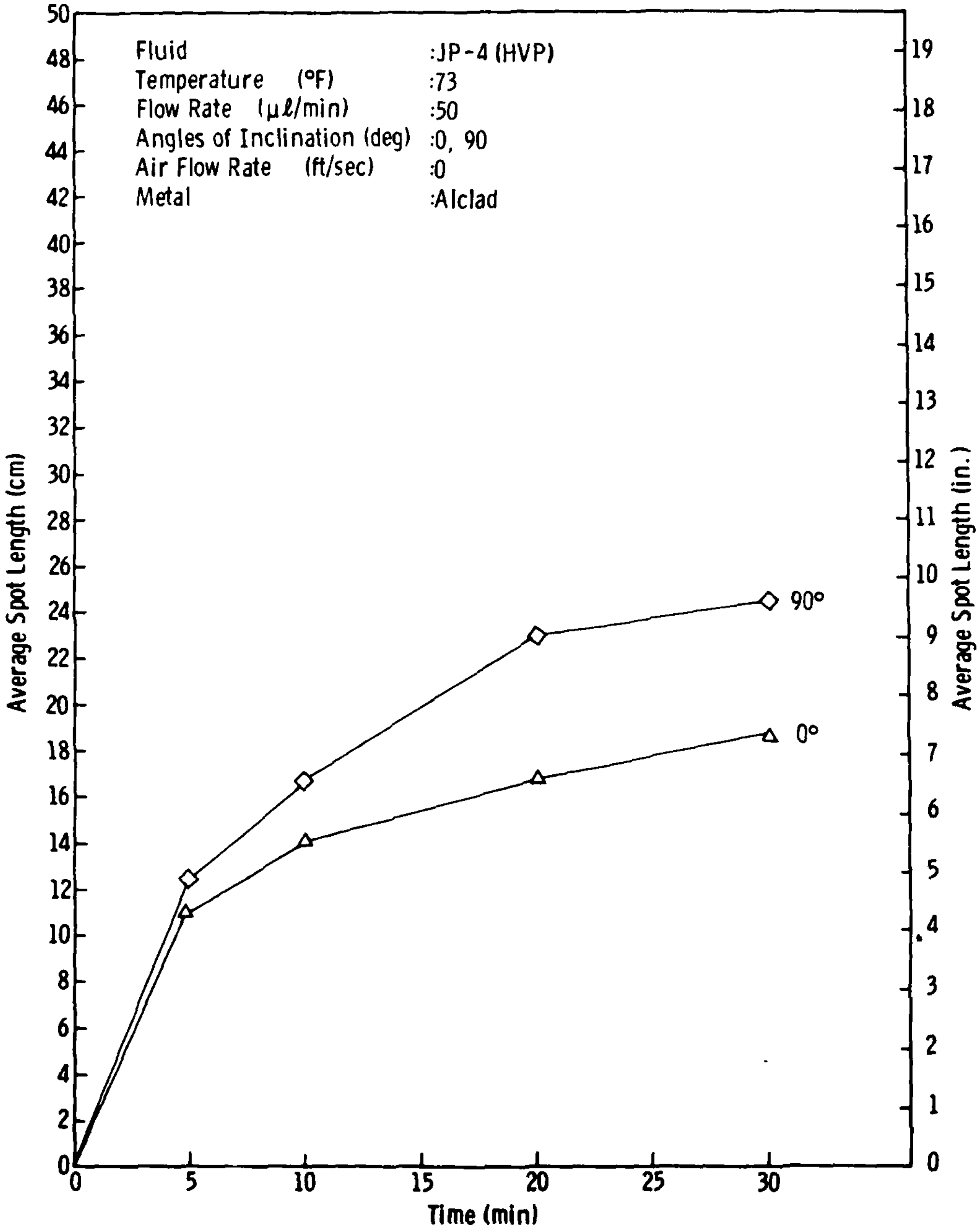

Fluid :JP-4 (HVP)
Temperature (°F) :73
Flow Rate (µℓ/min) :50
Angles of Inclination (deg) :0, 90
Air Flow Rate (ft/sec) :0
Metal :Alclad
90°
0°
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30

Figure 88.

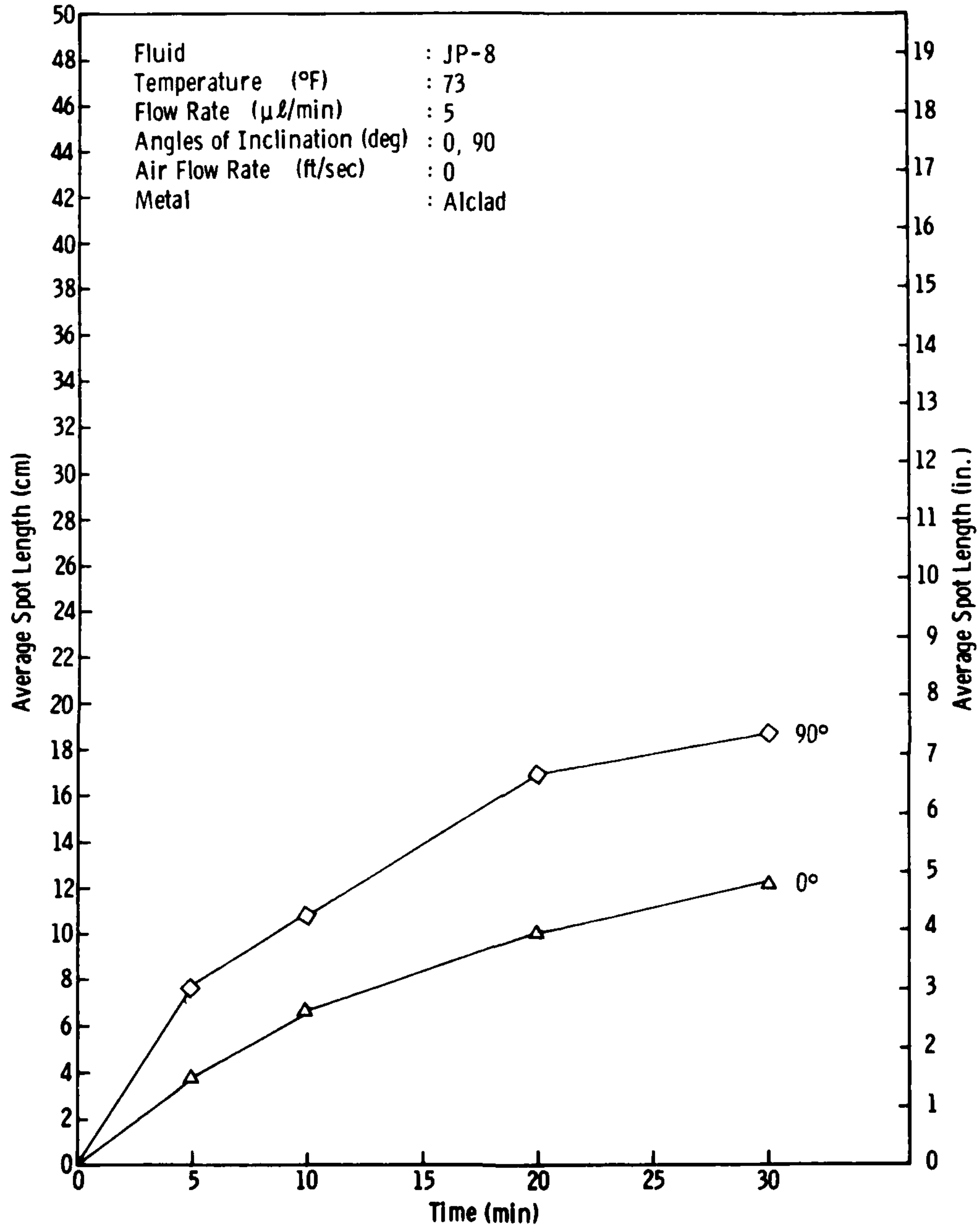
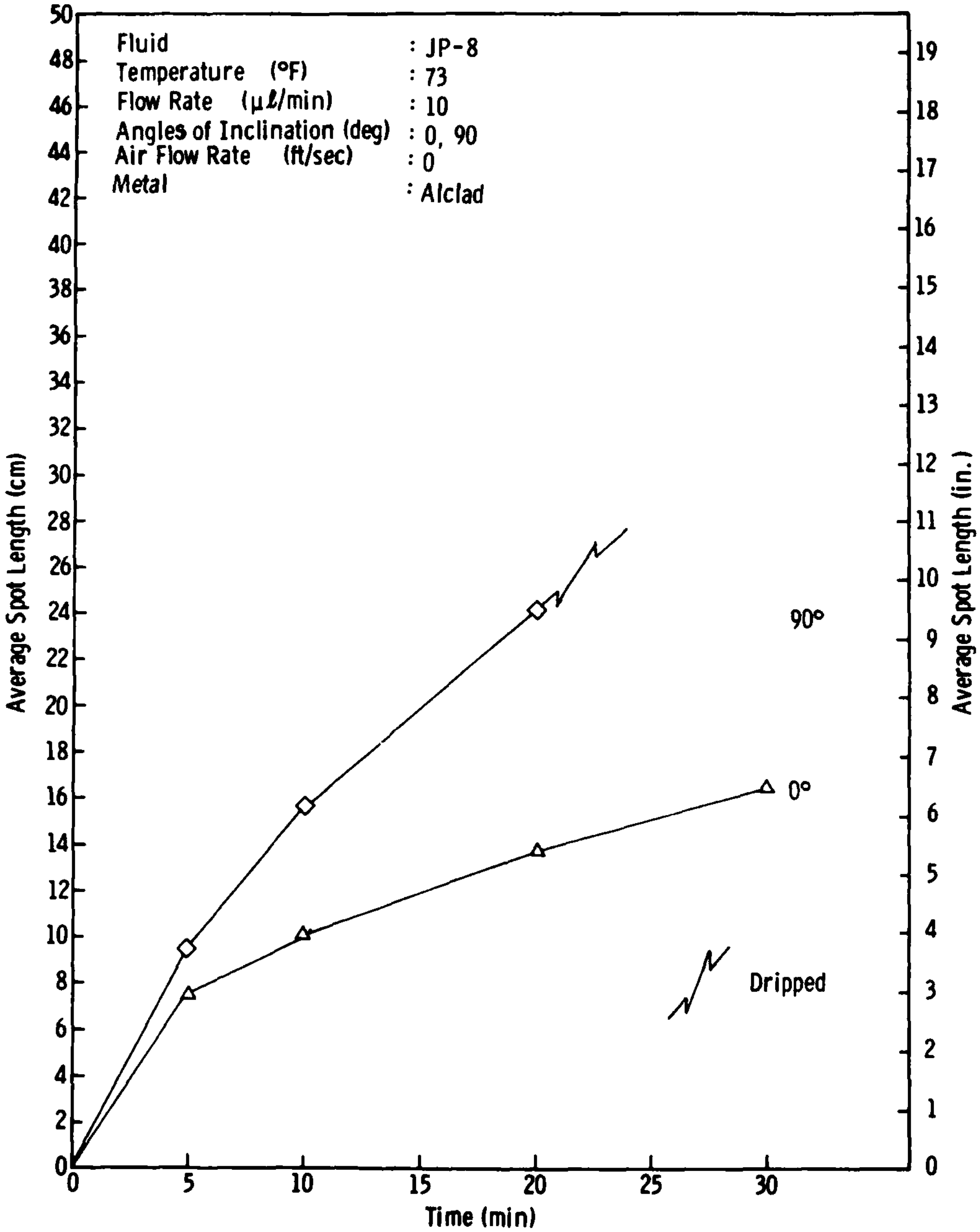
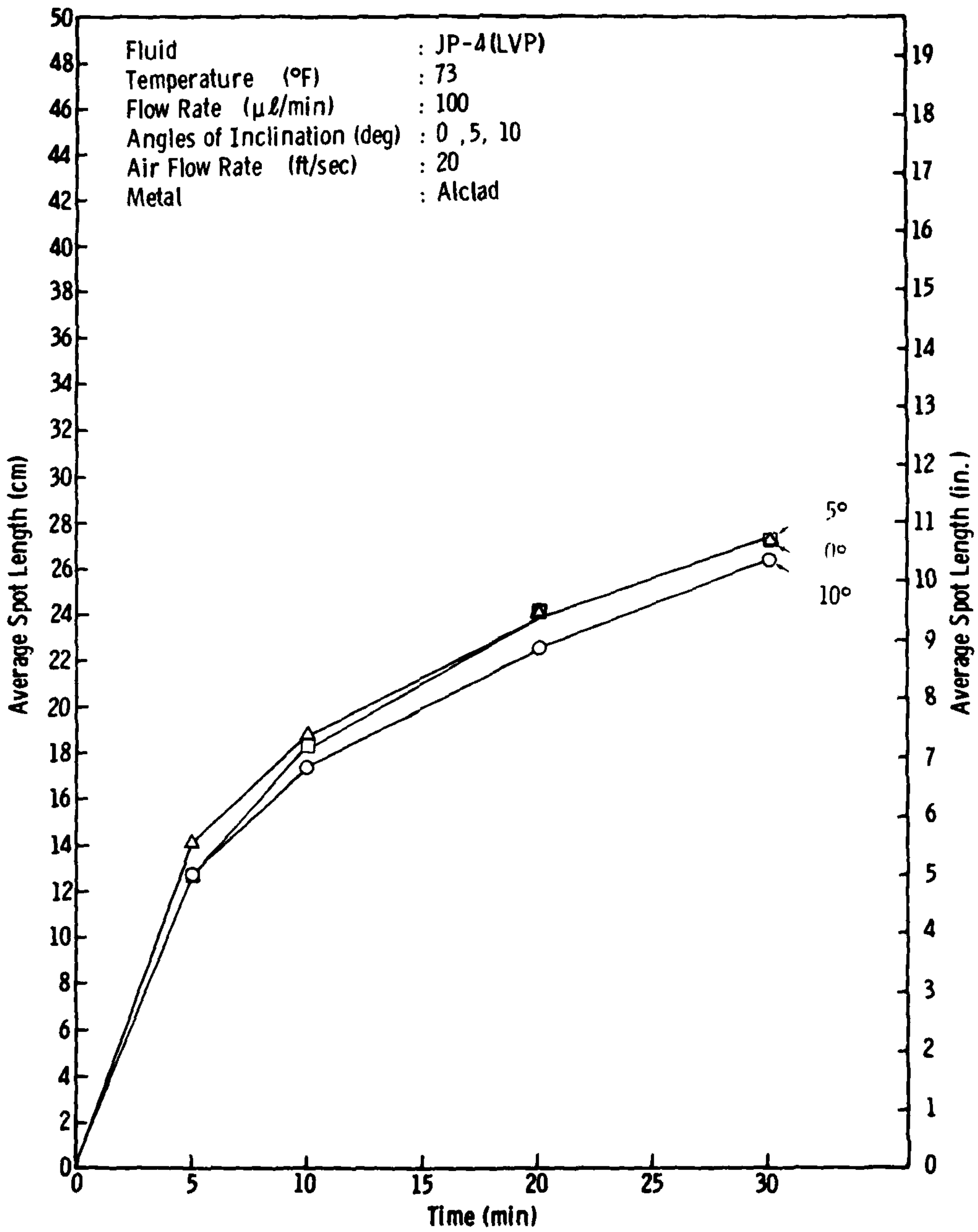

Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 5
Angles of Inclination (deg) : 0, 90
Air Flow Rate (ft/sec) : 0
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
90°
0°

Figure 89.



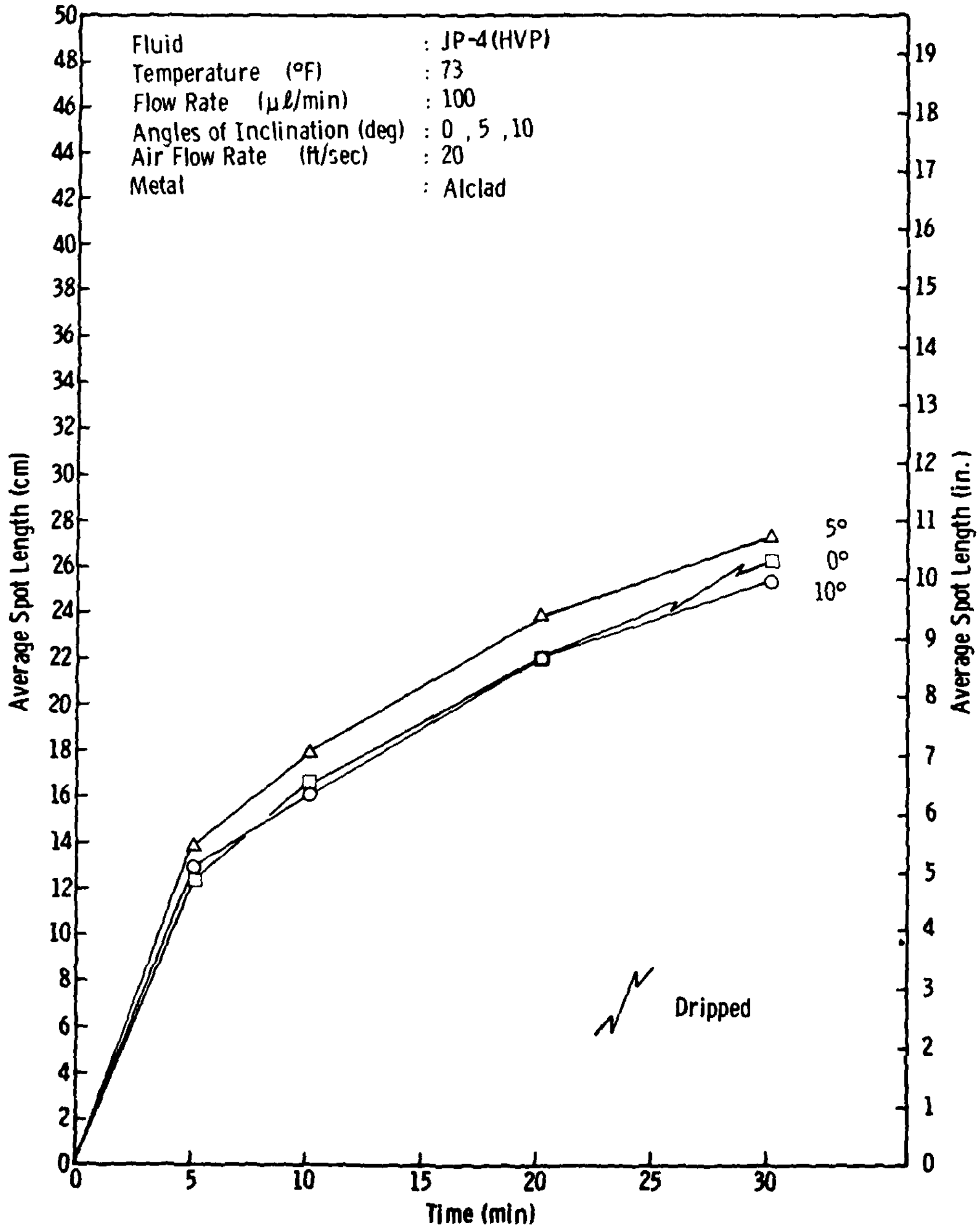
Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angles of Inclination (deg) : 0, 90
Air Flow Rate (ft/sec) : 0
Metal : Alclad
90°
0°
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
3
5
7
9
11
13
15
17
19
25


Figure 90.



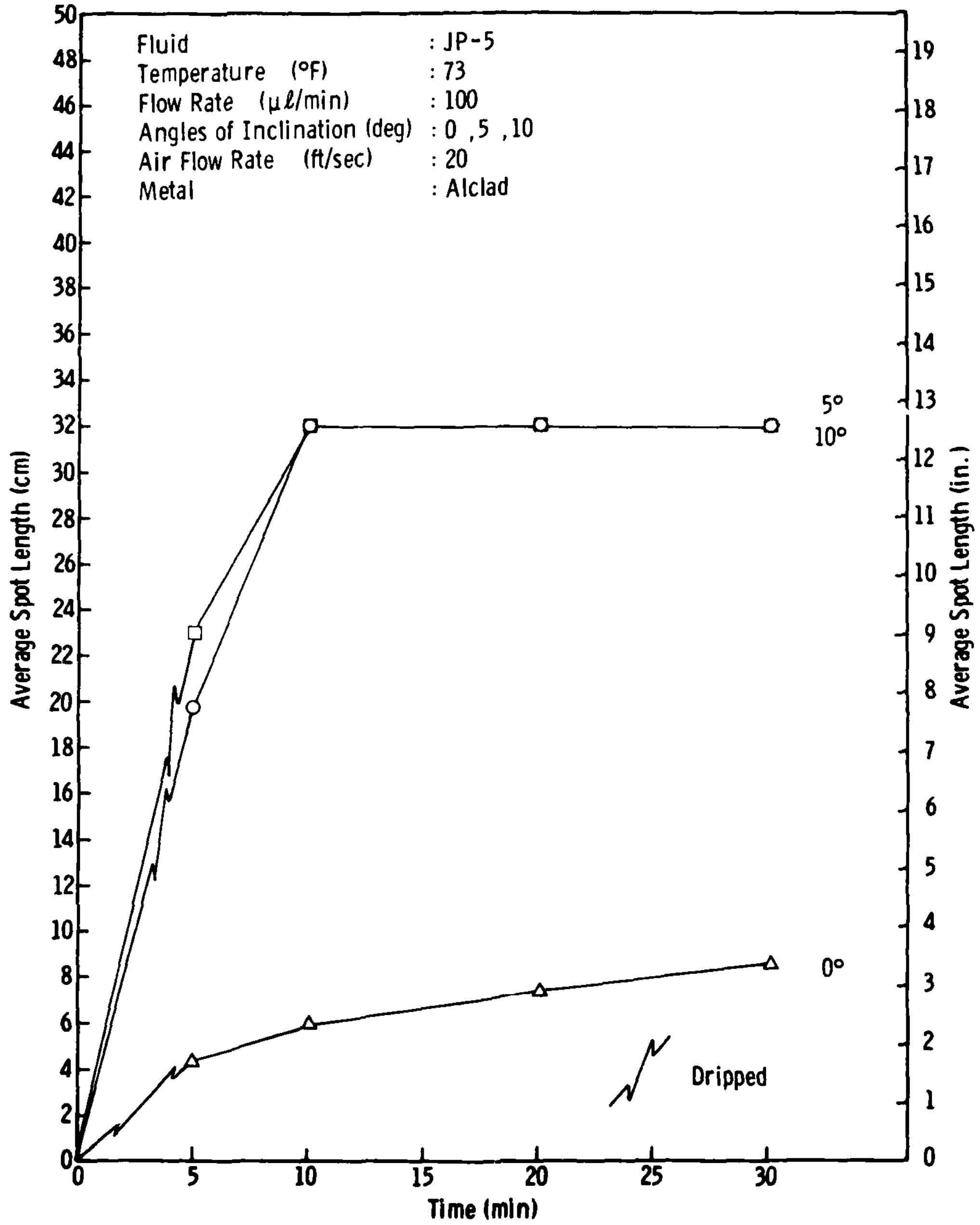
Fluid : JP-4(LVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angles of Inclination (deg) : 0 ,5, 10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
5°
0°
10°
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
0
5
10
15
20
25
30


Figure 91.



Fluid : JP-4(HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angles of Inclination (deg) : 0 , 5 , 10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
5°
0°
10°
Dripped


Figure 92.



Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
5°
10°
0°
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 93.

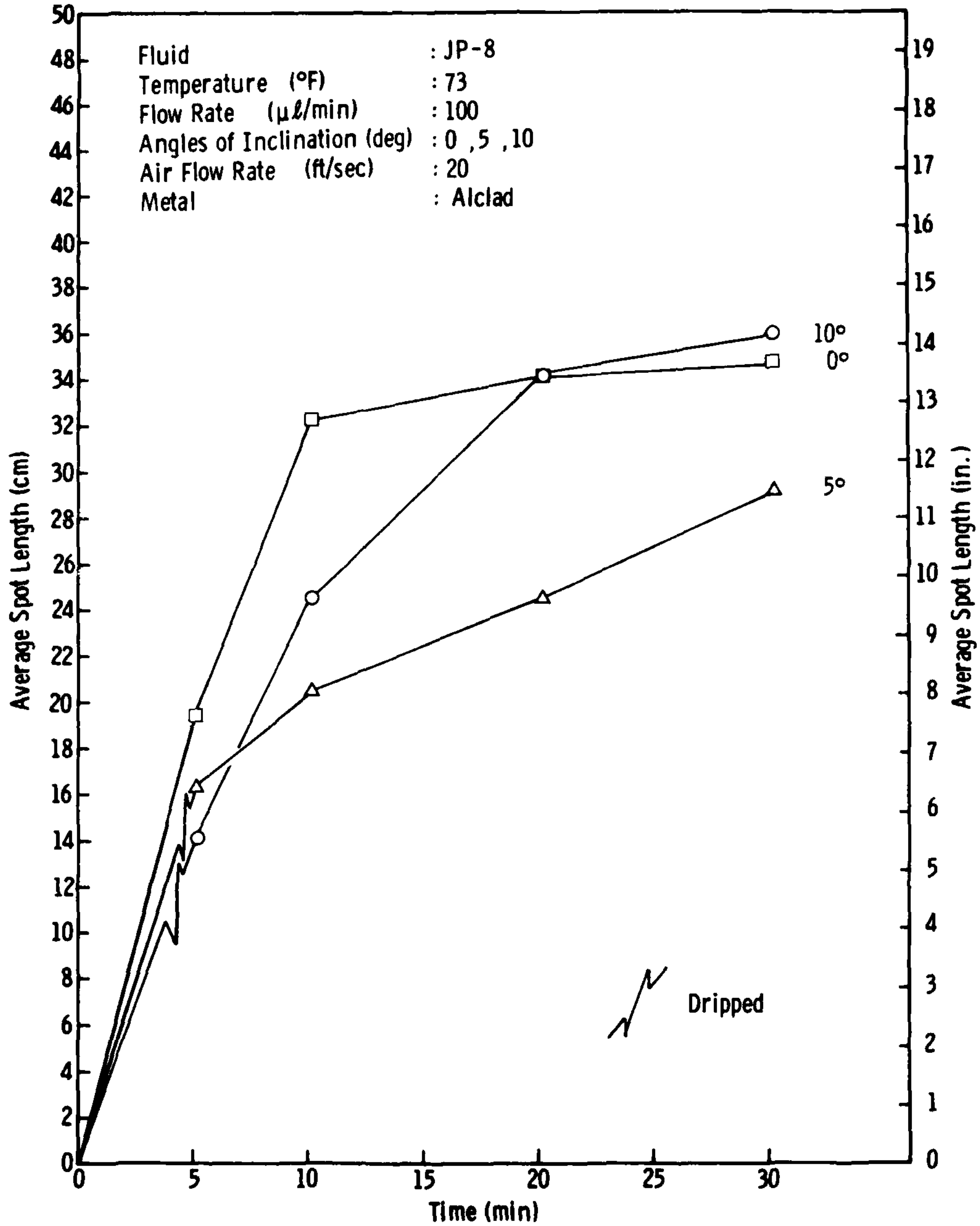
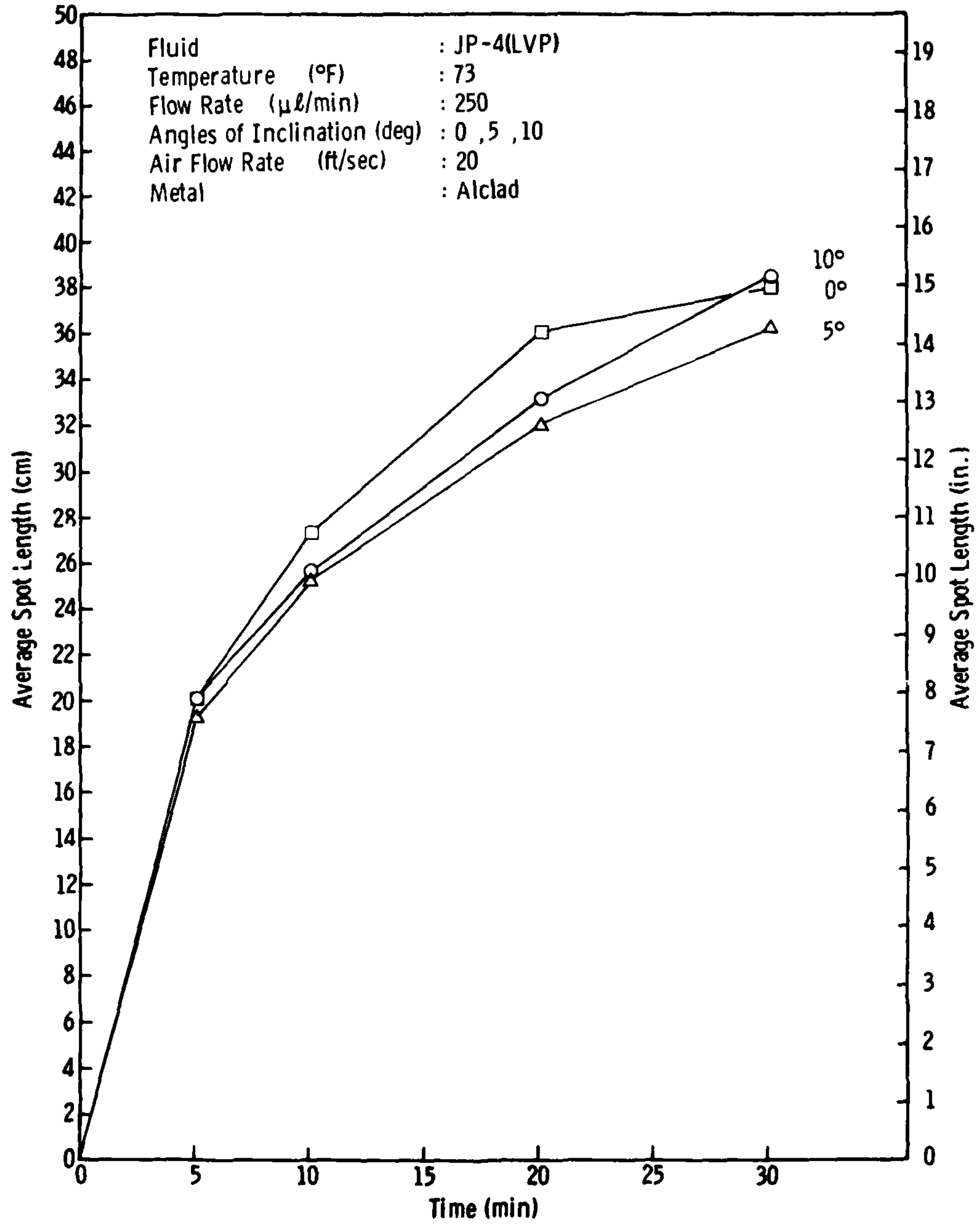
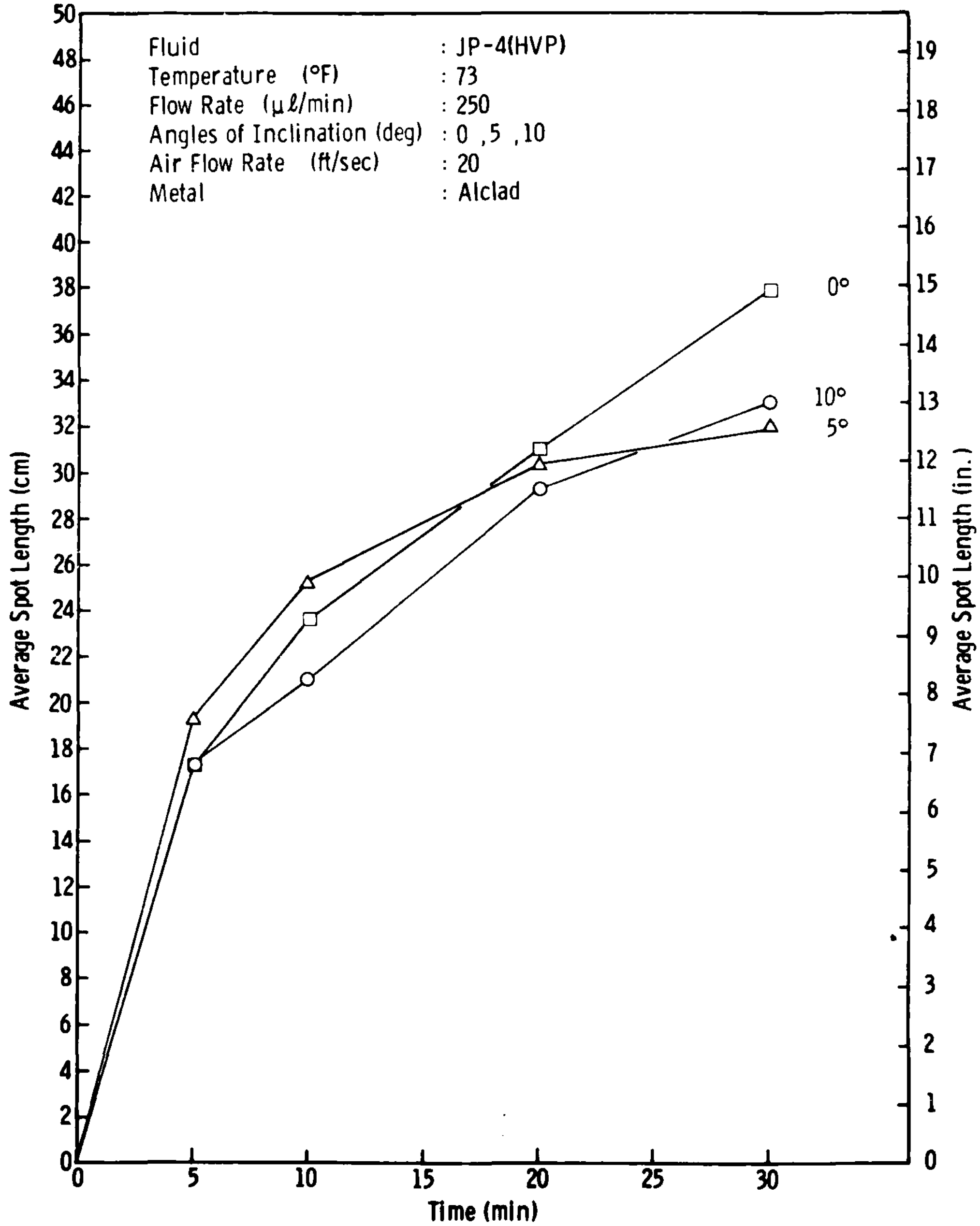

Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
10°
0°
5°
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 94.



Fluid : JP-4(LVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 250
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
10°
0°
5°
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 95.



Fluid : JP-4(HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 250
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
0°
10°
5°
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 96.

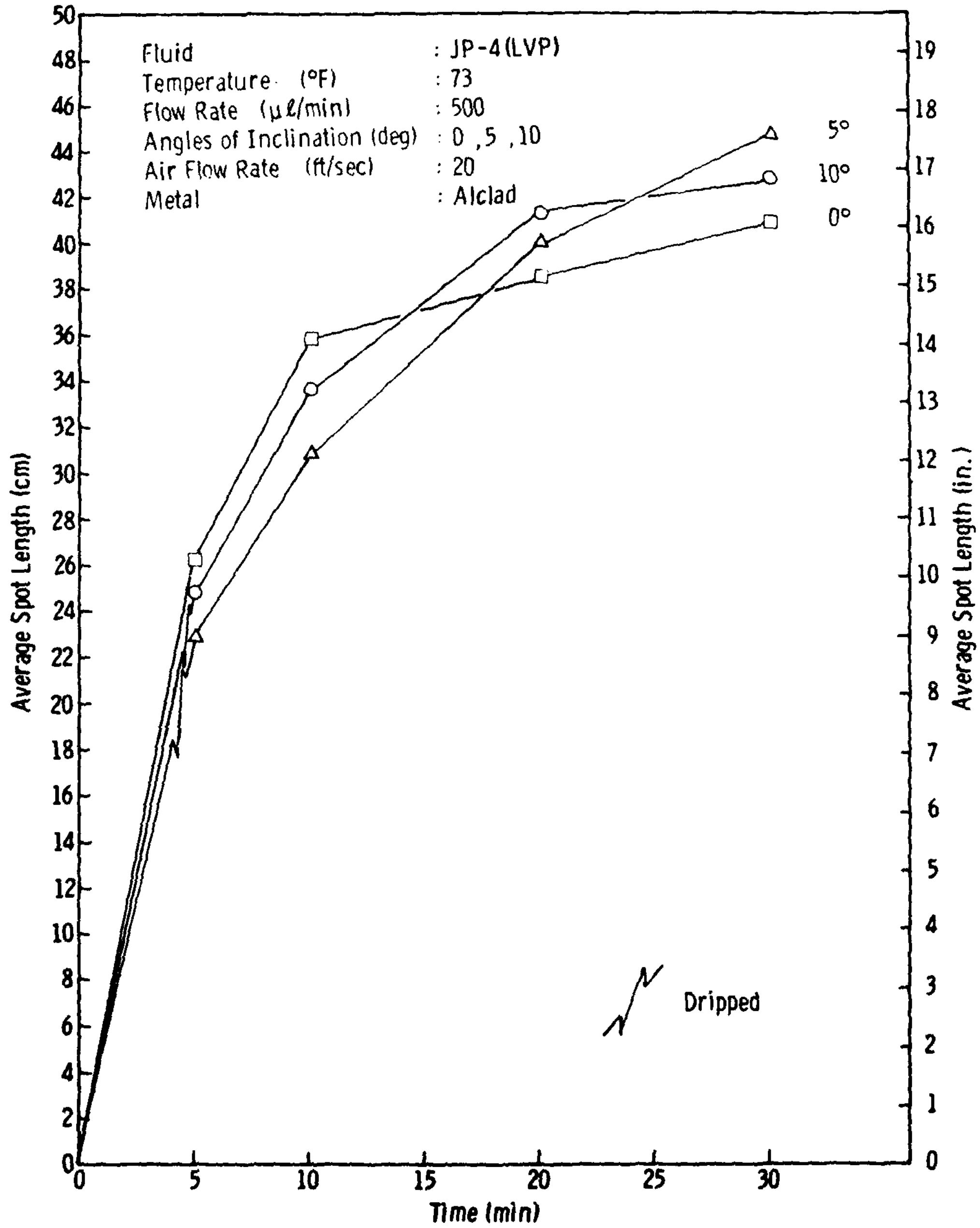
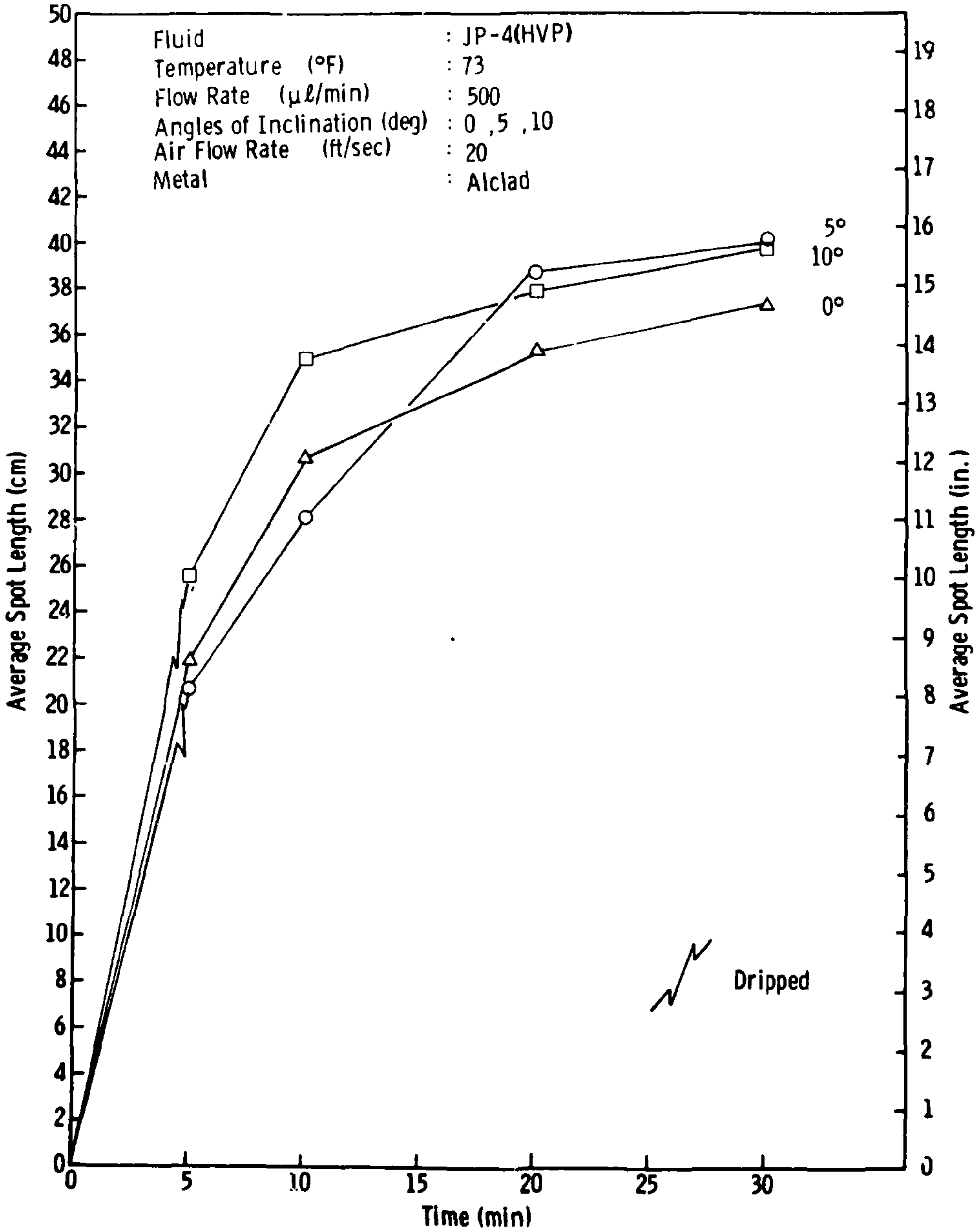
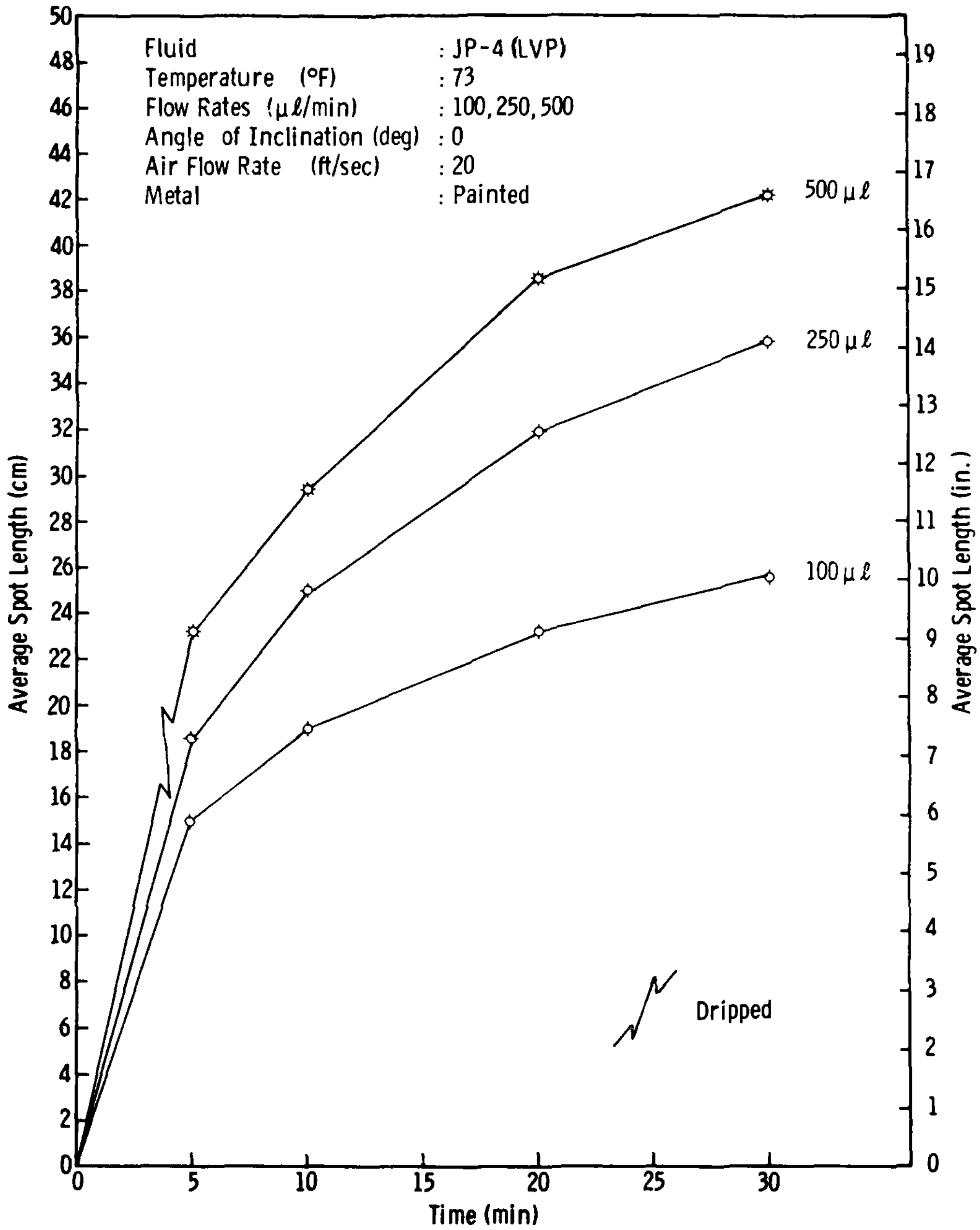

Fluid : JP-4(LVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 500
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
5°
10°
0°
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 97.



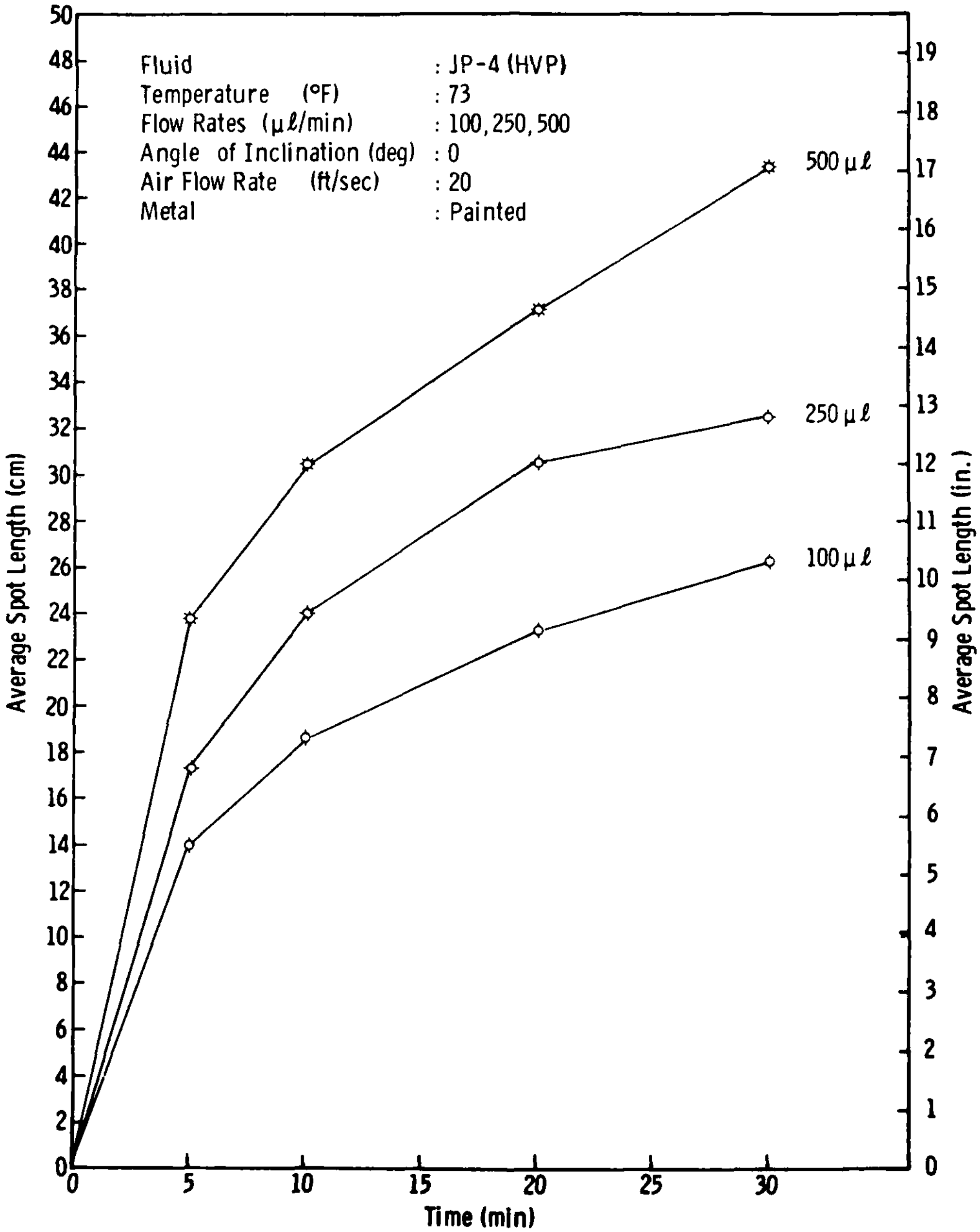
Fluid : JP-4(HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 500
Angles of Inclination (deg) : 0 ,5 ,10
Air Flow Rate (ft/sec) : 20
Metal : Alclad
5°
10°
0°
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)


Figure 98.



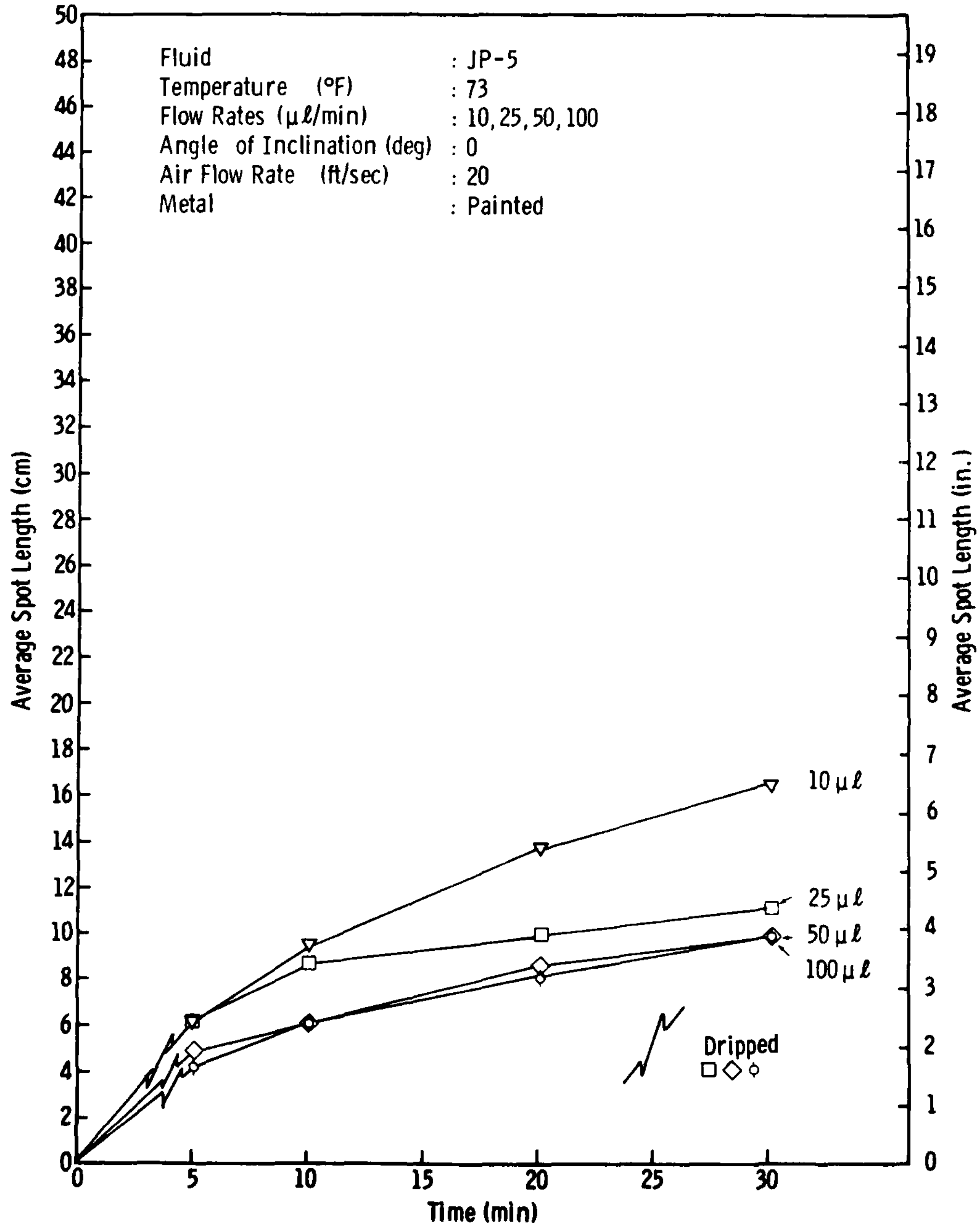
Fluid : JP-4 (LVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 100, 250, 500
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Painted
500 μℓ
250 μℓ
100 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 99.



Fluid : JP-4 (HVP)
Temperature (°F) : 73
Flow Rates (μℓ/min) : 100, 250, 500
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Painted
500 μℓ
250 μℓ
100 μℓ
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 100.



Fluid : JP-5
Temperature (°F) : 73
Flow Rates (μℓ/min) : 10, 25, 50, 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Painted
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
10 μℓ
25 μℓ
50 μℓ
100 μℓ
Dripped
0 5 10 15 20 25 30
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Figure 101.

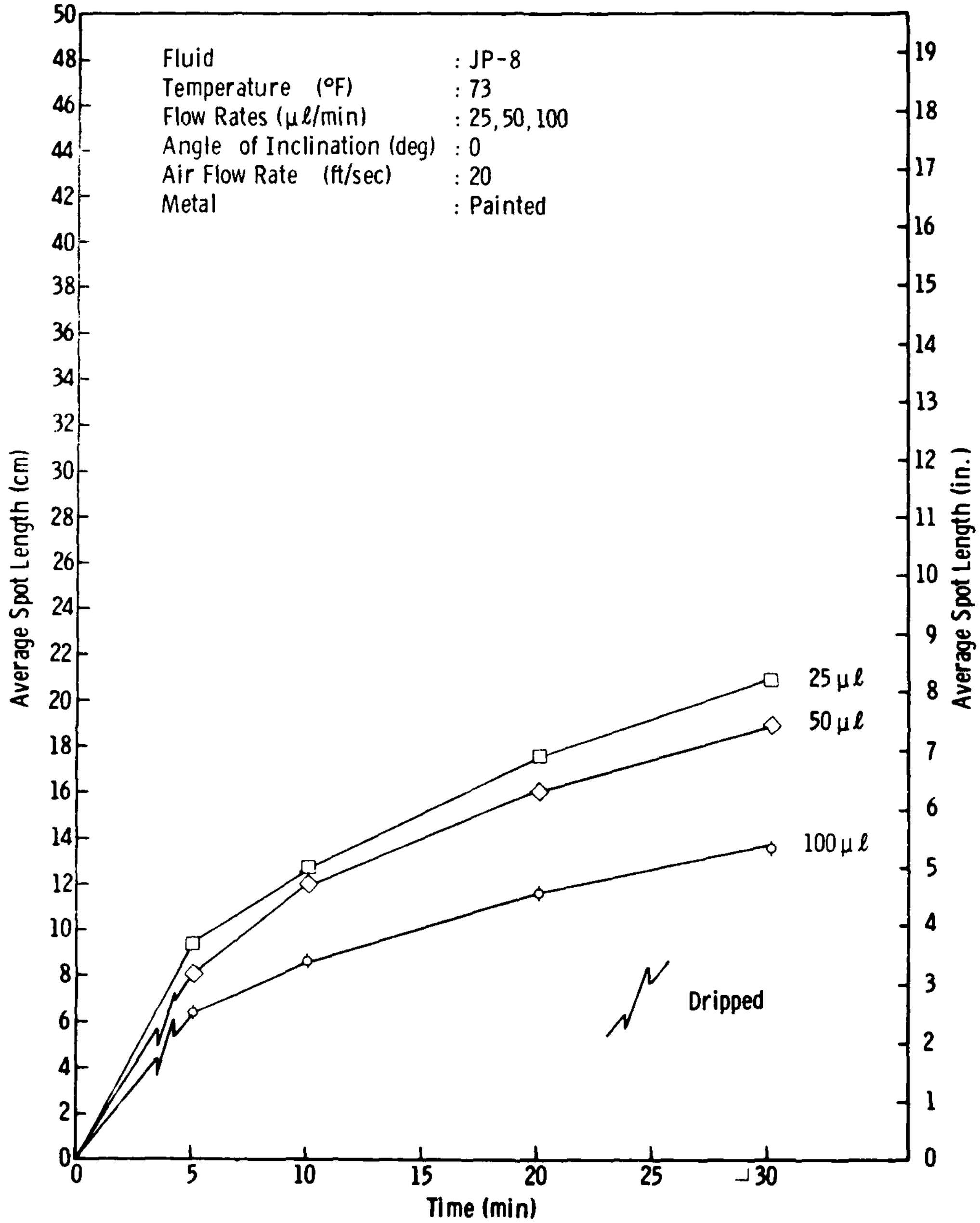

Fluid : JP-8
Temperature (°F) : 73
Flow Rates (μℓ/min) : 25, 50, 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Painted
25 μℓ
50 μℓ
100 μℓ
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

Figure 102.

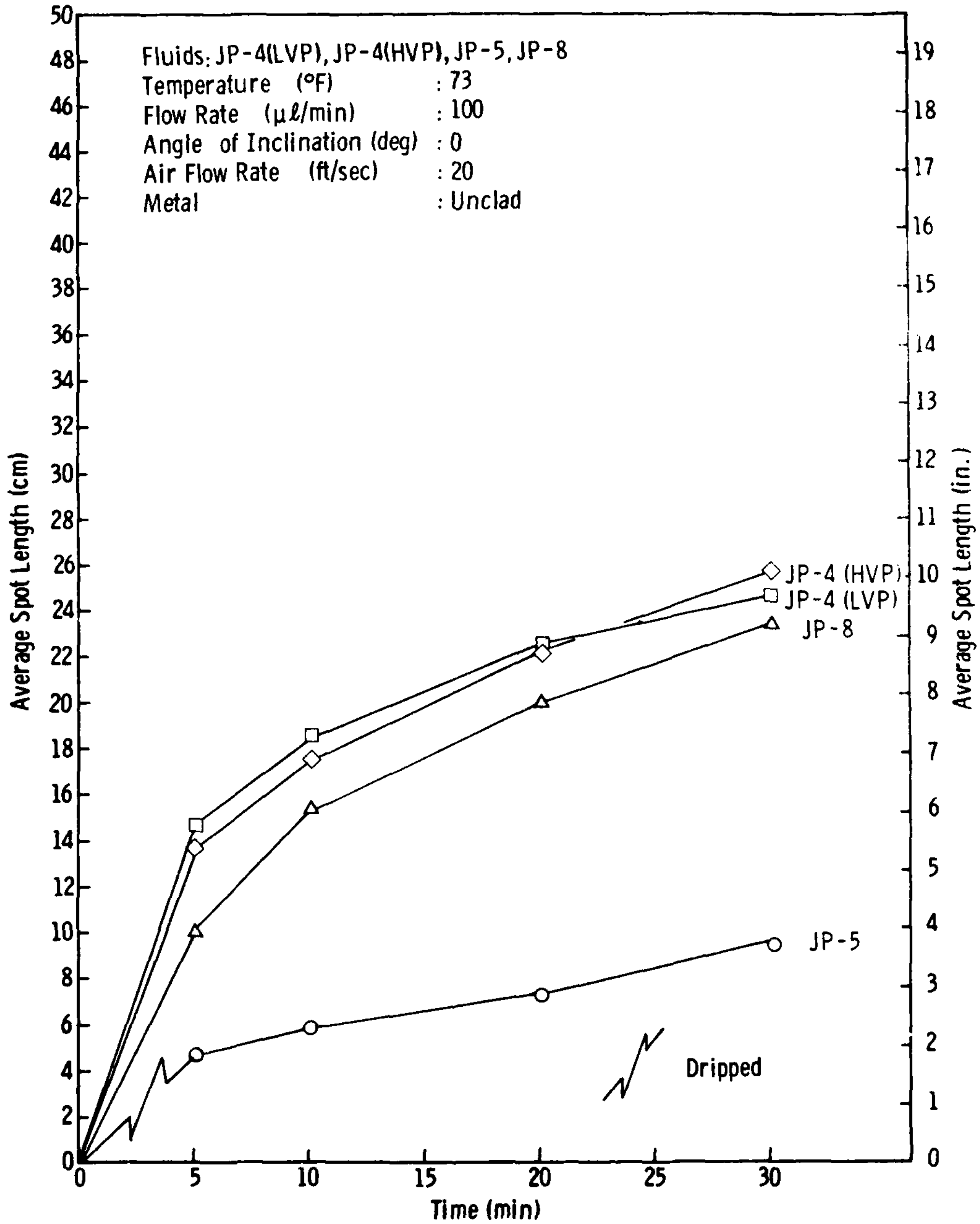

Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Unclad
JP-4 (HVP)
JP-4 (LVP)
JP-8
JP-5
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 103.

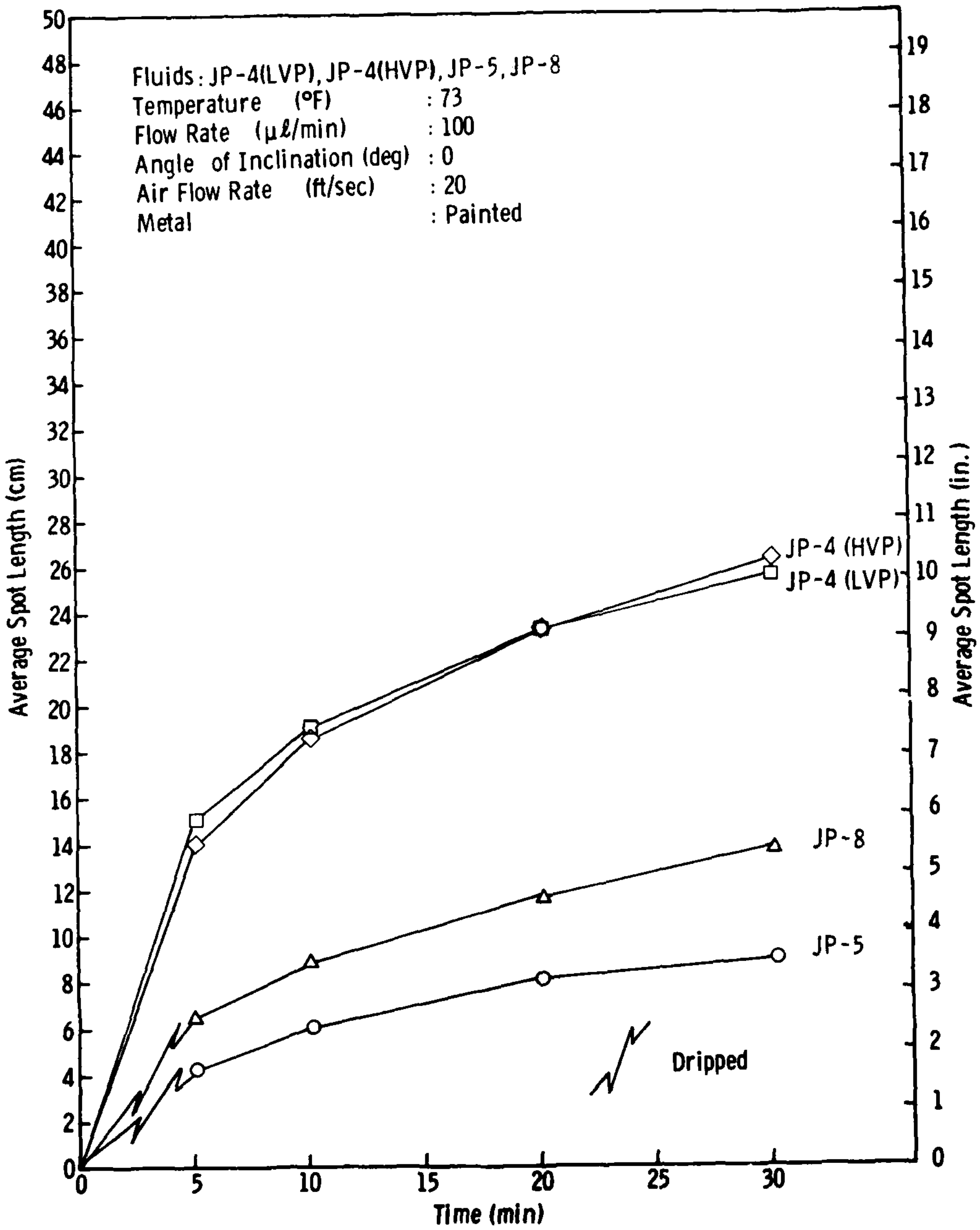

Fluids: JP-4(LVP), JP-4(HVP), JP-5, JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metal : Painted
JP-4 (HVP)
JP-4 (LVP)
JP-8
JP-5
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 104.

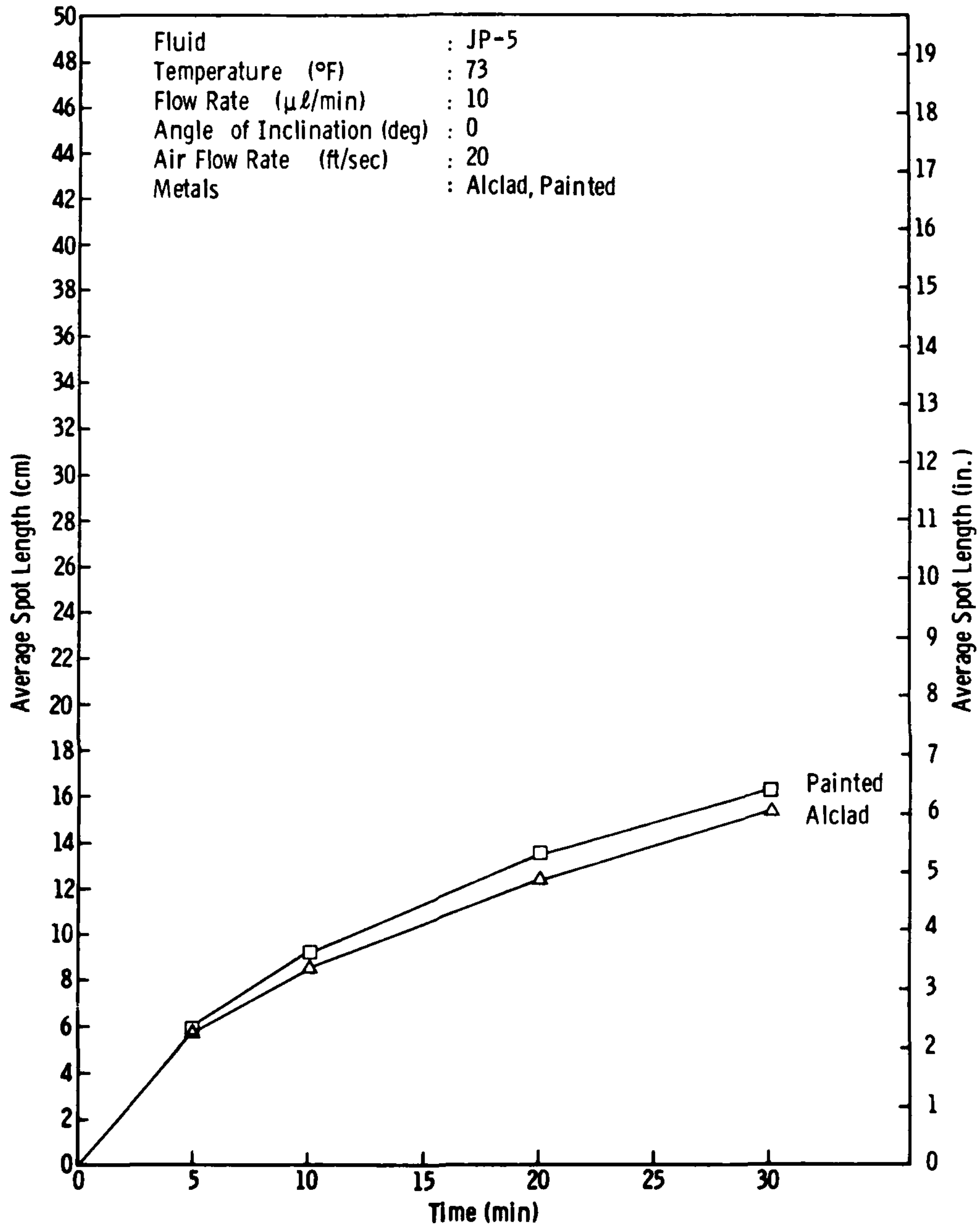

Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 10
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Painted
Painted
Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 105.

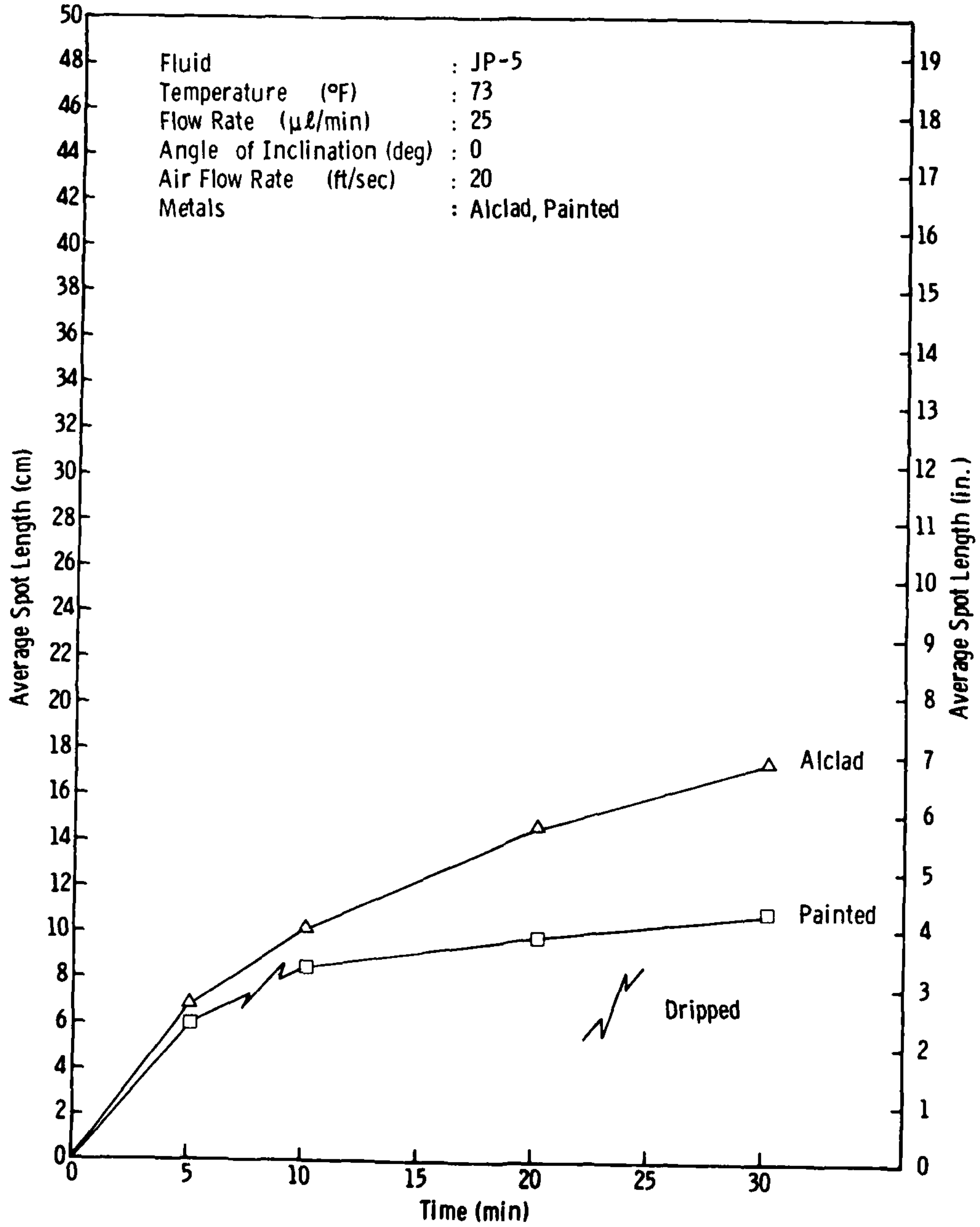

Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 25
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Painted
Alclad
Painted
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 106.

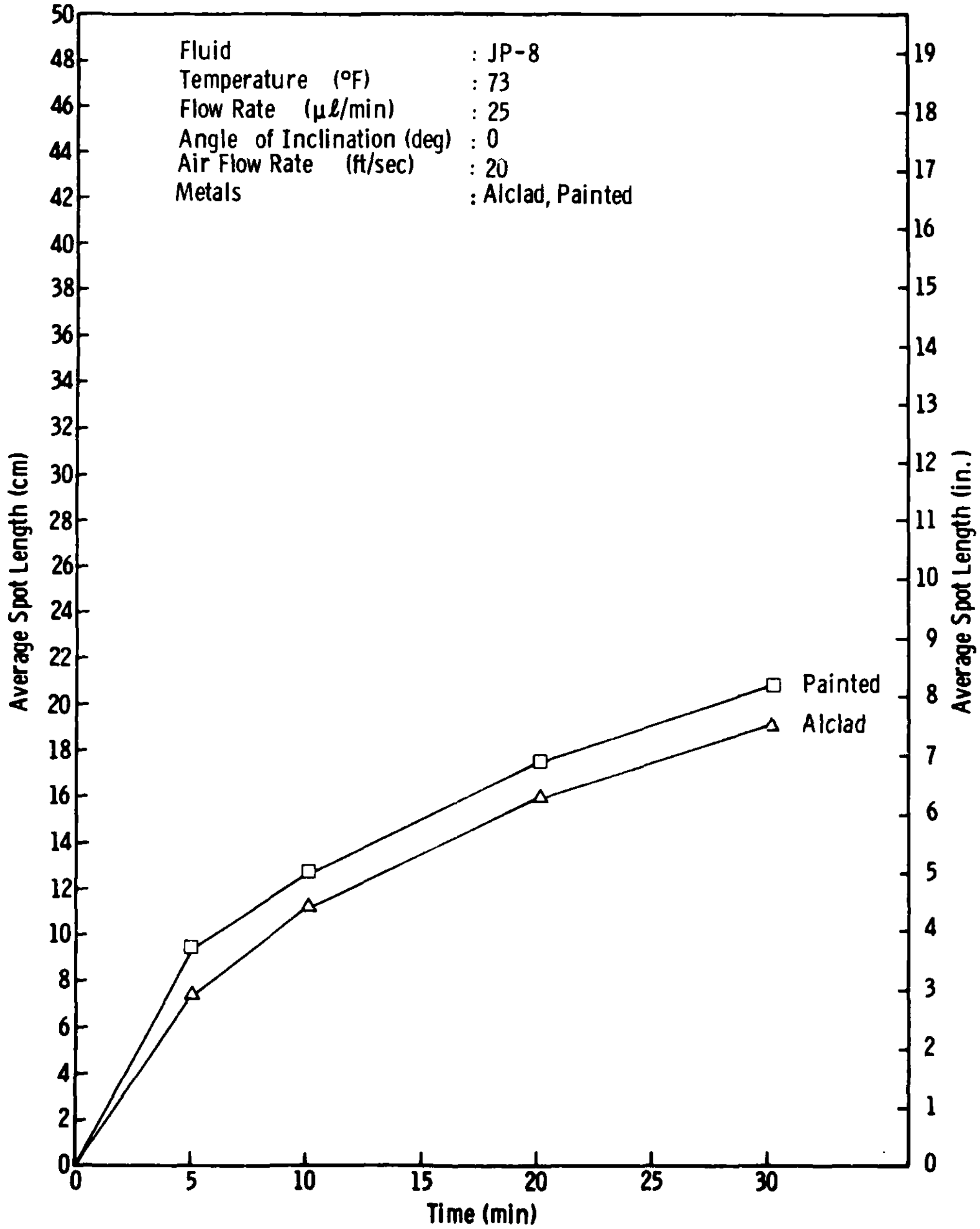
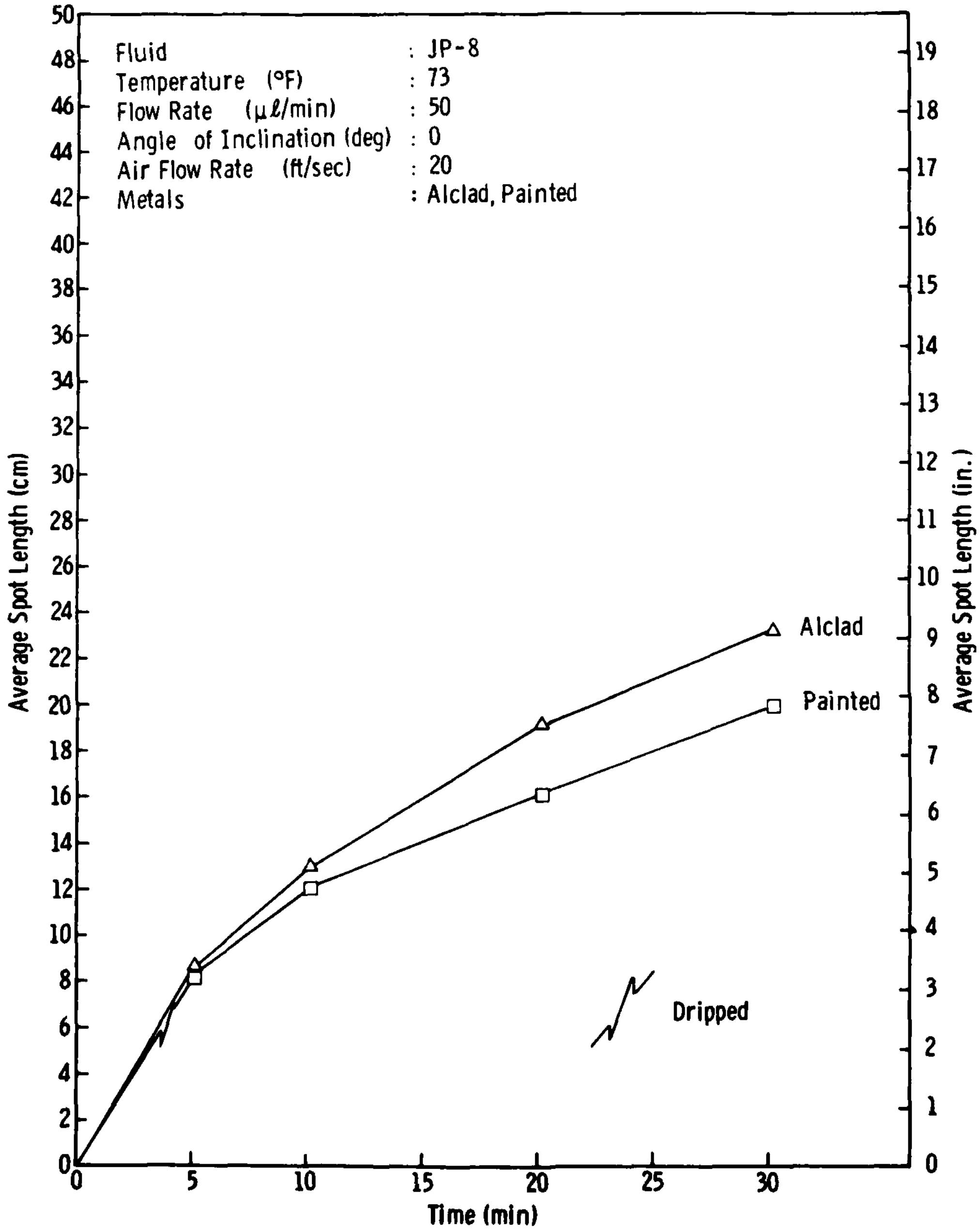
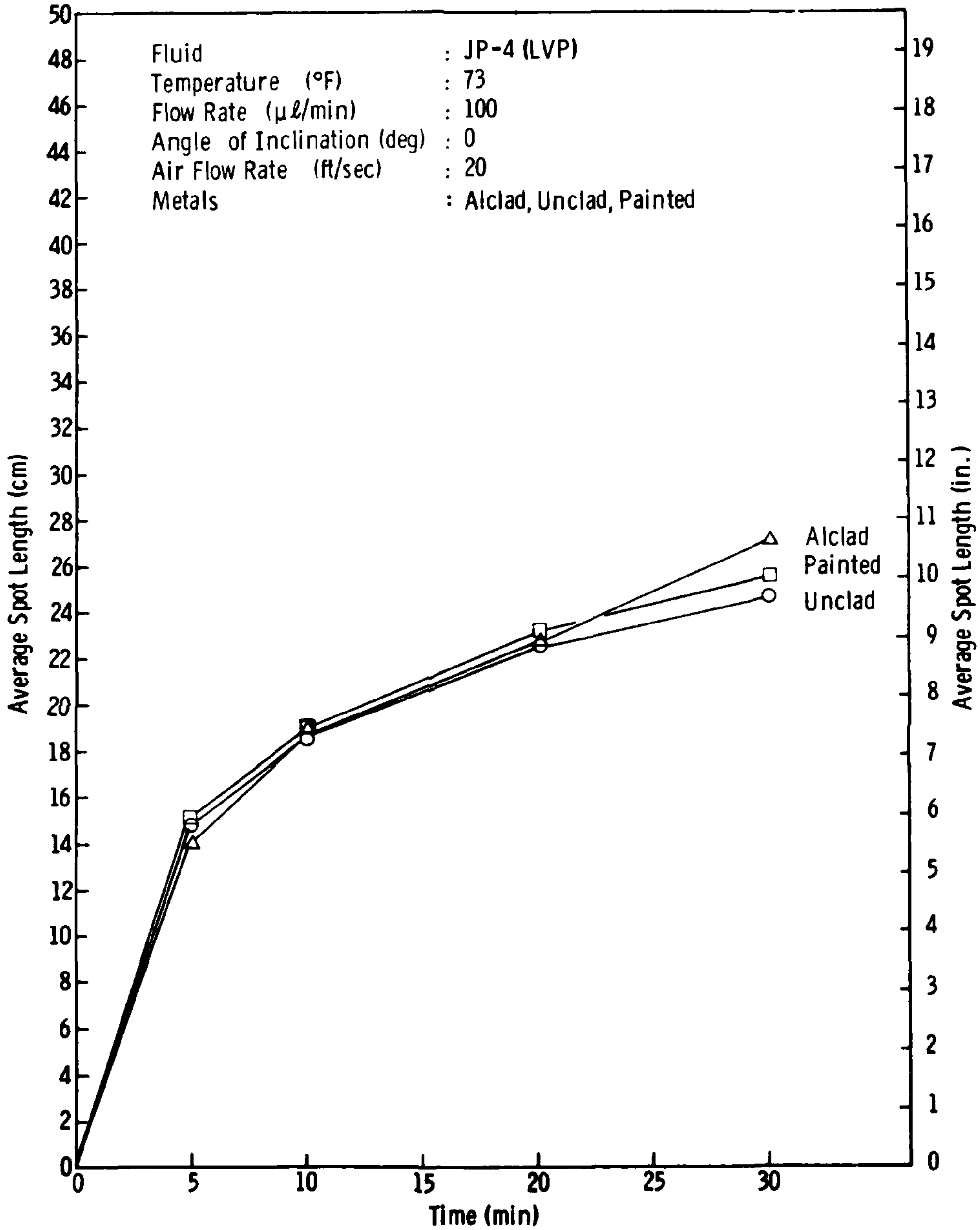

Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 25
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Painted
Painted
Alclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)

Figure 107.



Fluid : JP-8
Temperature (°F) : 73
Flow Rate (μℓ/min) : 50
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Painted
Alclad
Painted
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 108.



Fluid : JP-4 (LVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Unclad, Painted
Alclad
Painted
Unclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30


Figure 109.

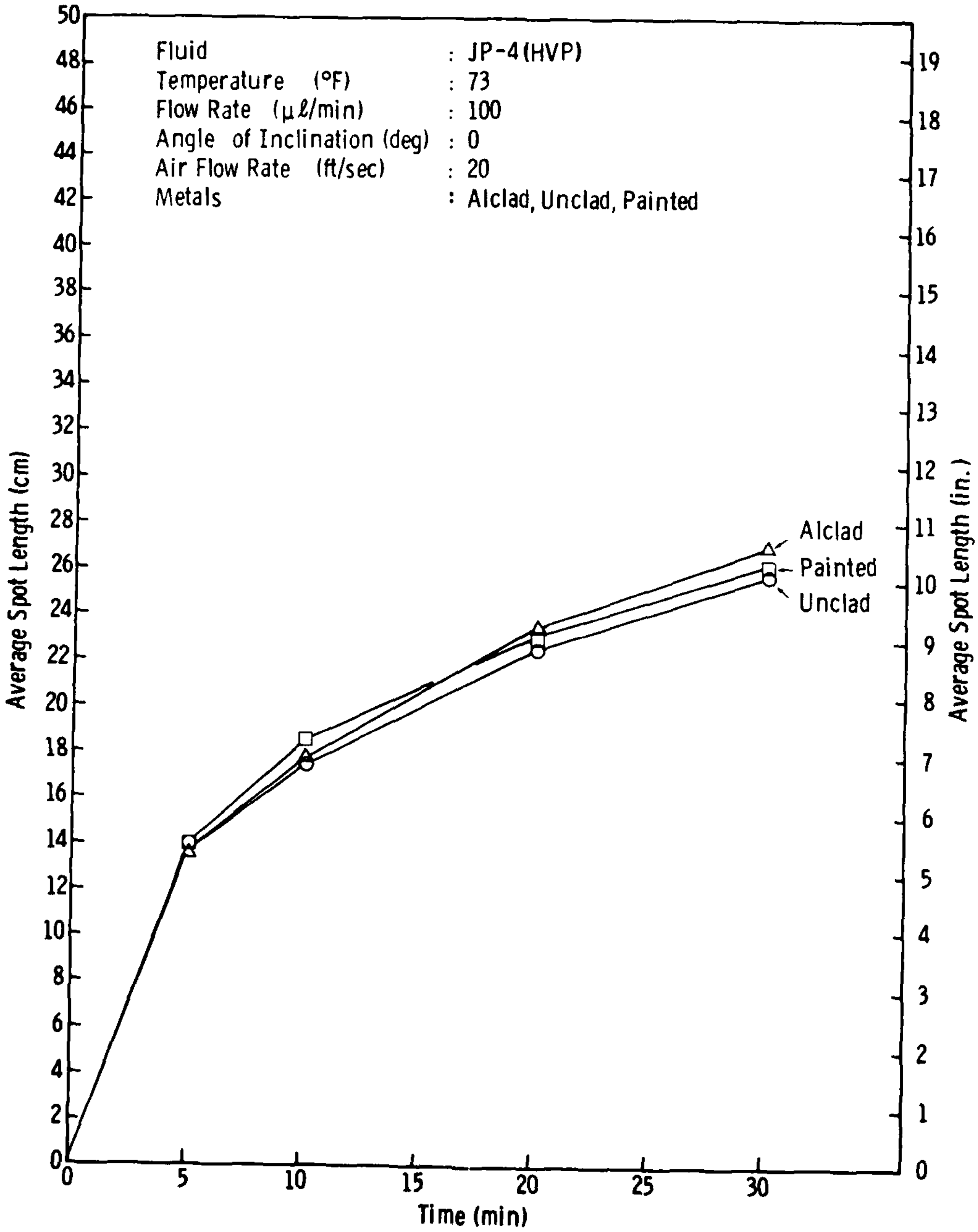

Fluid : JP-4(HVP)
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Unclad, Painted
Alclad
Painted
Unclad
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Figure 110.

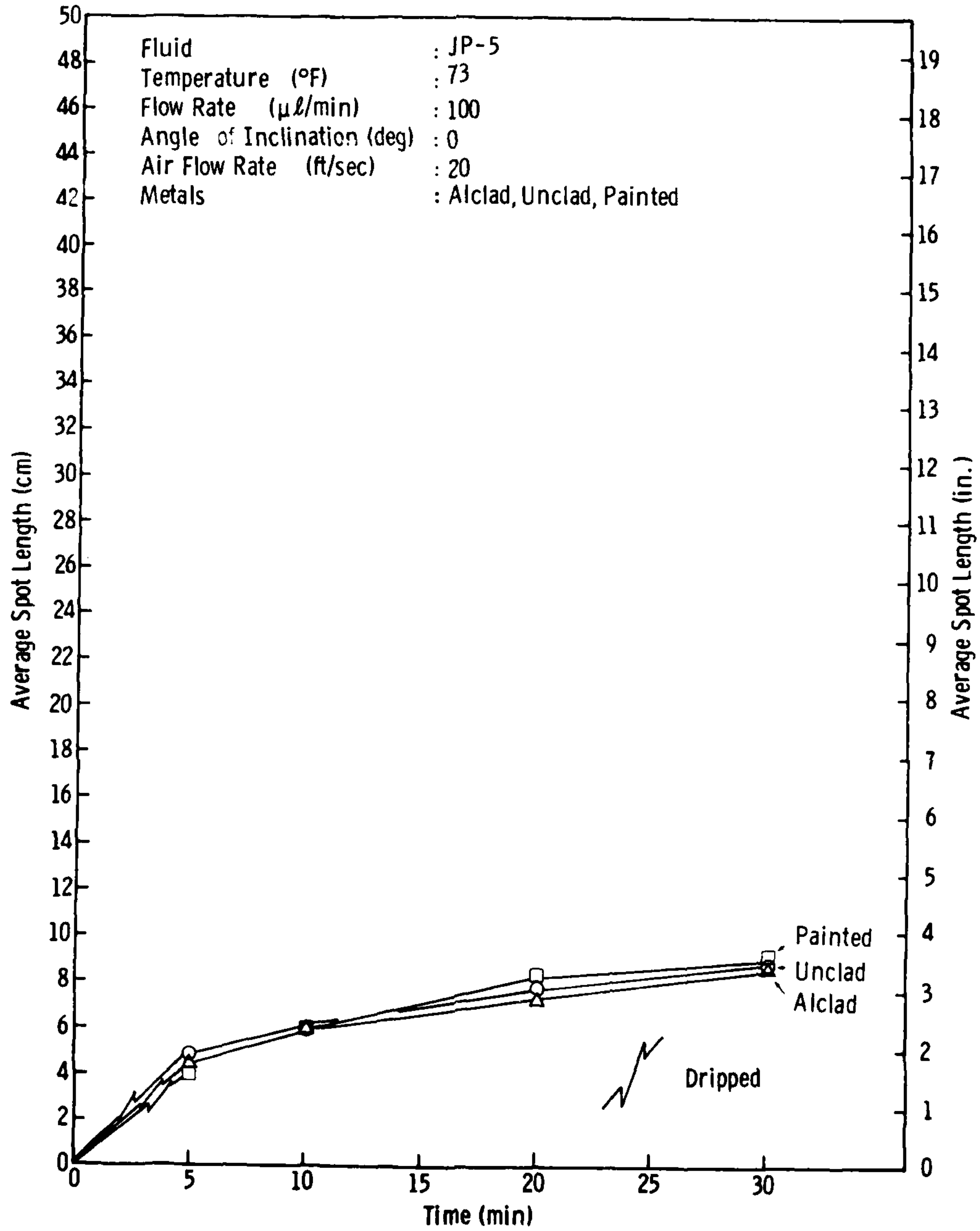

Fluid : JP-5
Temperature (°F) : 73
Flow Rate (μℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Unclad, Painted
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
Painted
Unclad
Alclad
Dripped
0
5
10
15
20
25
30

Figure 111.

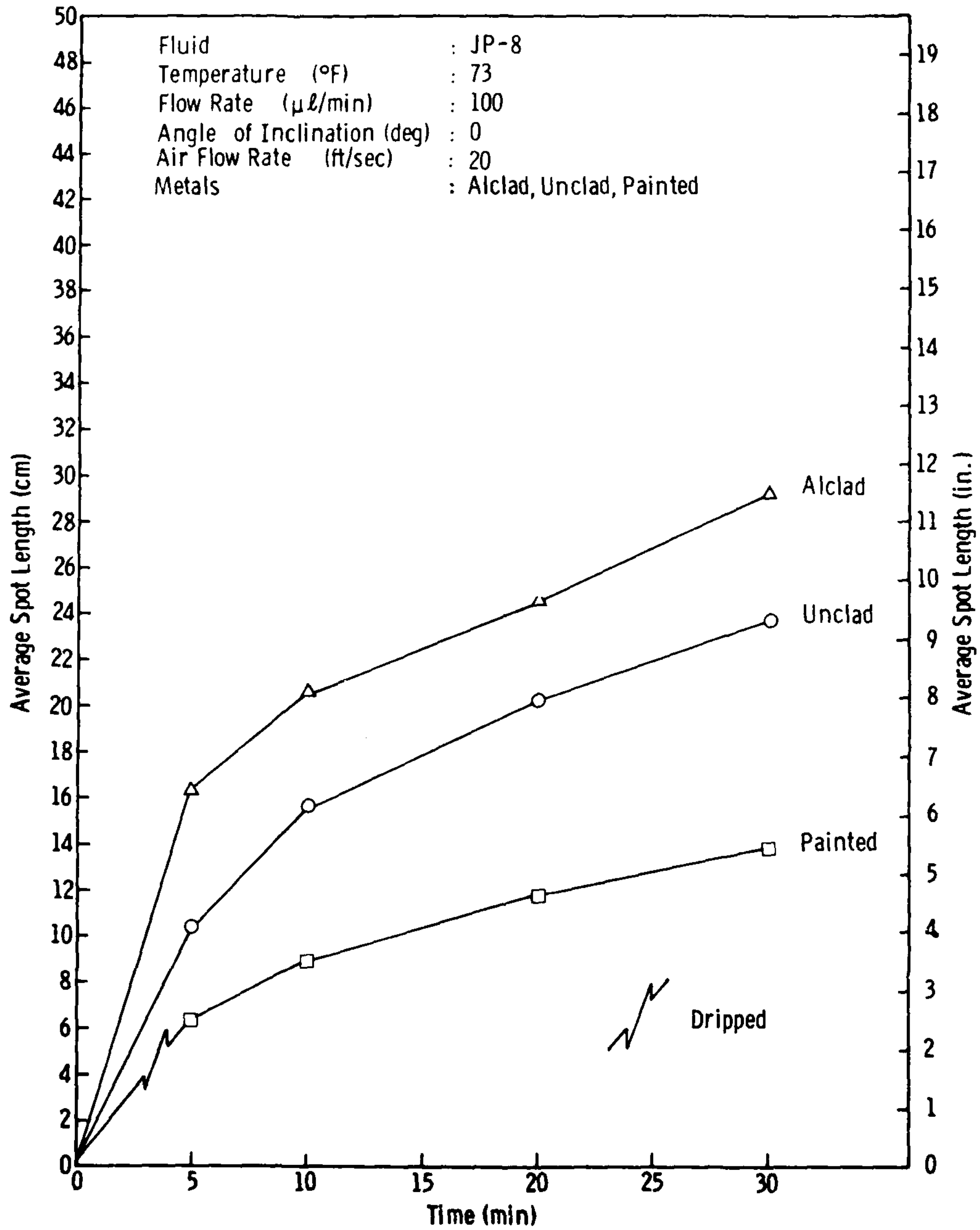

Fluid : JP-8
Temperature (°F) : 73
Flow Rate (µℓ/min) : 100
Angle of Inclination (deg) : 0
Air Flow Rate (ft/sec) : 20
Metals : Alclad, Unclad, Painted
Alclad
Unclad
Painted
Dripped
Average Spot Length (cm)
Average Spot Length (in.)
Time (min)
0
5
10
15
20
25
30
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

Figure 112.

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